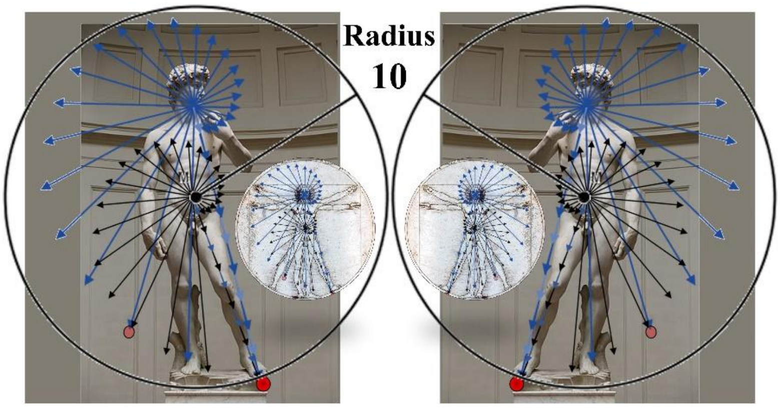
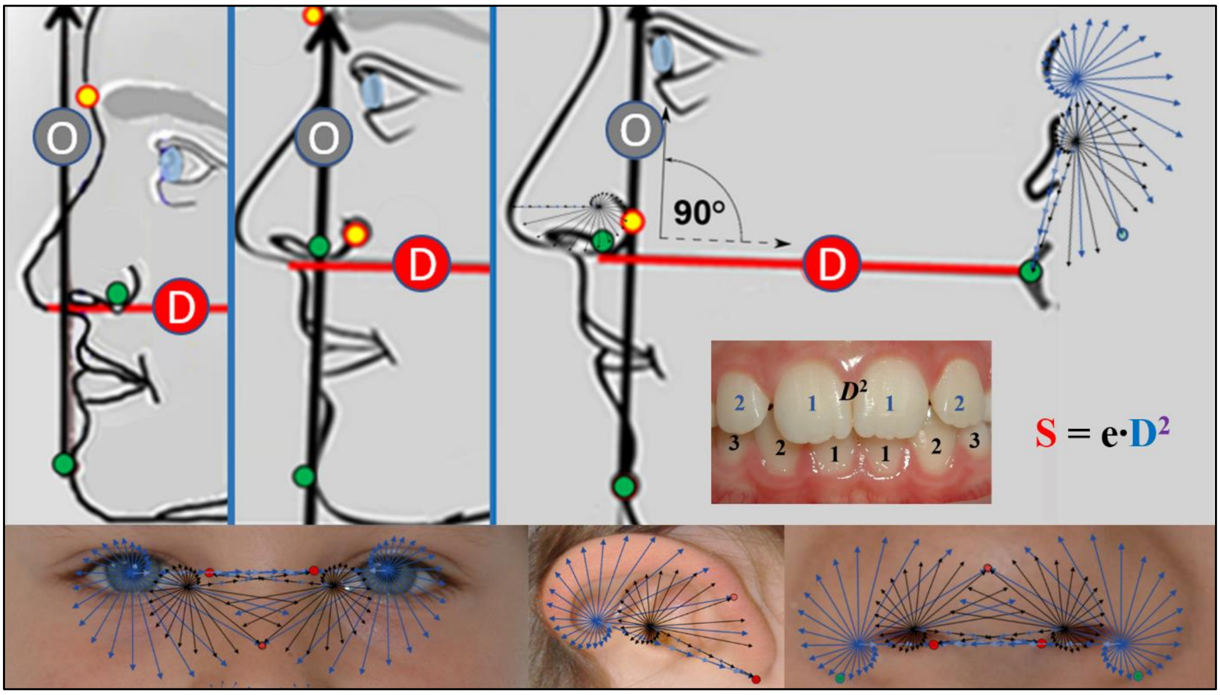


The Norma Classification for Mandible Size



The Morphological Maxilla as Basis for a Tooth Orthopedic Diagnosis

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FOREWORDS

This book is addressed to the Swiss National Foundation to remind it that what matters is not where science is done, but whether the scientist is hiding truths or not. Otherwise, his work only helps himself and not the community.

As a 19-year-old man, I developed the theory that creation (God) had given the universe a mathematically detectable tool in the form of gravity to create man in his own image: **My structural theory of gravitation**. This theory germinated from the contemplation of a drawing by Leonardo da Vinci (1452-1519), with which he described mathematical patterns in human proportions, and a fresco painting by Michelangelo Buonarroti (1475-1564), with which he depicted the shaping of man by God (**Fig. A**).

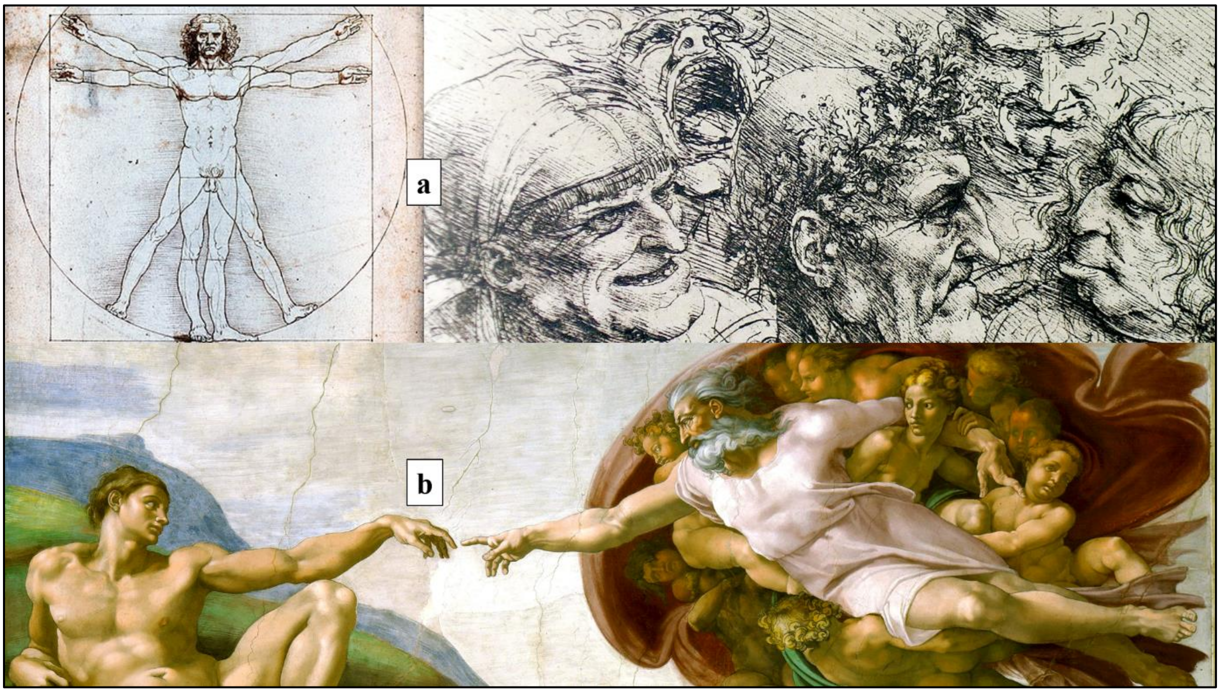


Figure A: *Leonardo and Michelangelo.* (**a**) shows the sketched drawing from a diary by Leonardo da Vinci (1490) on the human physique and its proportions, which is still a symbol of aesthetics not only in the Renaissance period, as well as one of his paintings entitled: Grotesque Heads. (**b**) shows one of nine frescoes in the Sistine Chapel by Michelangelo Buonarroti on the first book of Moses – Genesis – entitled: The Creation of Adam.

In 1997 I successfully completed my studies in dentistry at the University of Bern. This was so that I could have subsequently become a specialist in orthodontics because, among other things, I also wanted to verify my theory of gravitation. Although I was on a waiting list for more than five years, I did not get a residency in Bern and then sought my fortune in my own practice for general dentistry in 7402 Bonaduz (Switzerland).

In 2007, I felt for the first time that I could see an initial confirmation of my theory of gravitation. I discovered that a that a double logarithmic spiral based on the first four numbers or the number 24 – here called a structionspiral –, fitted the facial structures of my four-year-old son quite well (**Fig. B**).

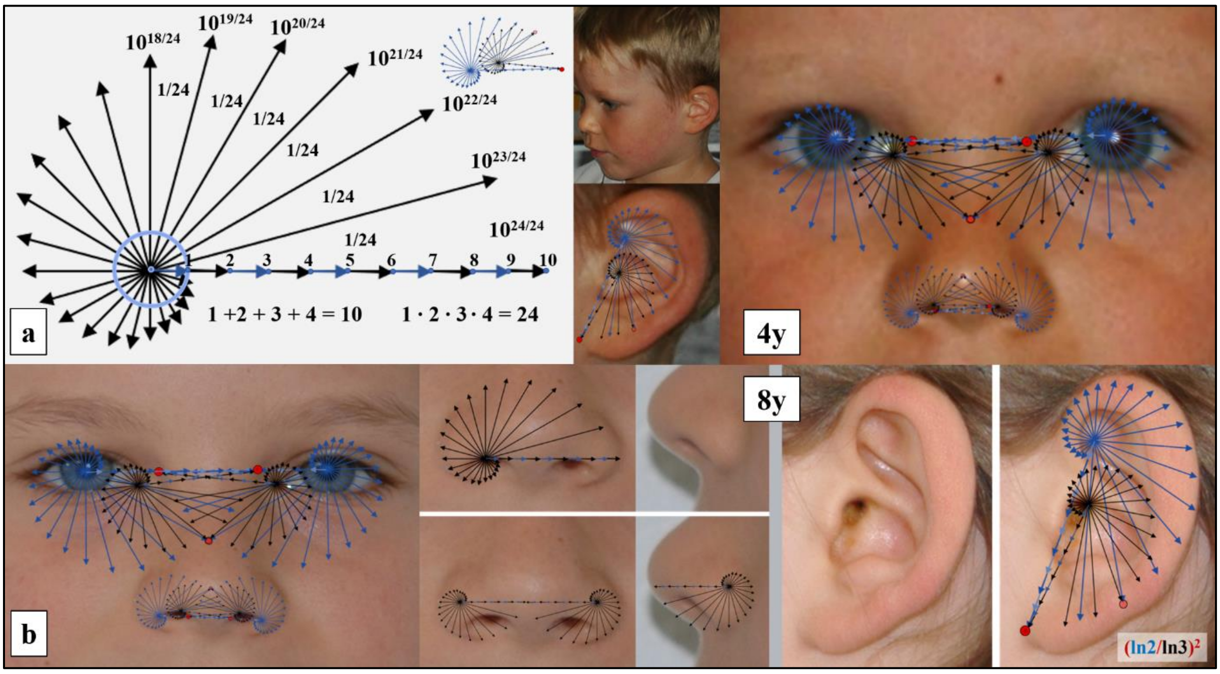


Figure B: *The structionspiral*. (**a**) shows a logarithmic spiral based on the first four numbers, which, after a fractal doubling and distortion-free superimposition as a struction spiral, fits the eyes, nostrils and ear of my then four-year-old son Joel amazingly well. Because Joel was not yet ready for standardised orthogonal photography in 2007, a second photo series was added here with (b) at the age of eight in order to demonstrate the amazing precision with which the struction spiral can be superimposed on facial structures. Particularly impressive is the ear, in which the smallest possible fractal dimension – the Hausdorff dimension D = ln2/ln3 – is focussed in a central point (most anterior point of attachment of the earlobe) in a dual growth formation of two logarithmic spirals as a structionspiral.

A comparison of a superimposed structionspiral on my son's ear with anatomical drawings of the ear stimulated my fantasy and led to the question: Is the upper of the two logarithmic spirals placed over the ear related to the organ of equilibrium and the lower of the two logarithmic spirals to the organ of hearing? If so, then there is a possible connection between the base number 24 and the relatively constant time of day of 24 hours, which arises thanks to the gravitational relationship of our earth to the solar system. All this strengthened my suspicion that our decimal system is a kind of fractal, which we recognise and use for counting thanks to the similar fingers plus two thumbs (**Fig. C**).

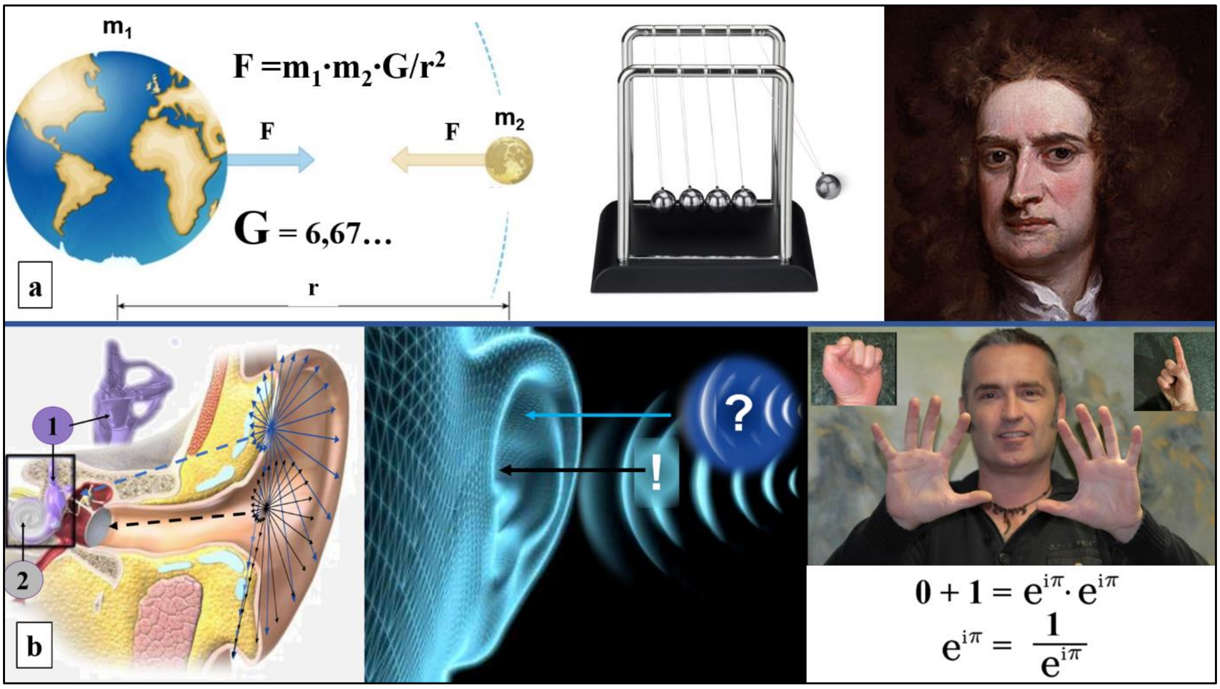


Figure C: *The decimal system as fractals of gravitation.* (**a**) shows Isaac Newton's calculation formula from 1687. It states that every point of mass acts on every other point of mass with an attracting gravitational force F. To calculate the gravitational force, it needs the gravitational constant G, which is still determined empirically today. (**b**) shows the ear-double function and my eight similar fingers (the thumb looks slightly different) with which I can represent binary or complex functions.

In 2008, I was almost certain that I could show, using representative mathematics, that the ear can perceive not only sound waves but also gravitational waves. At that time, however, gravitational waves were still a conjecture and had not been discovered, and because of my seemingly esoteric theory, I did not know how to prove a causal connection according to the Bradford-Hills criteria (Hill AB. The environment and disease: association or causation. Proc R Soc Med 1965; 58:295-300), for example, I could have investigated a link between balance disorders and "old" ears. At least I was sure that the nostrils and the ear could be useful as a reference for a facial classification.

In 2009, I sought my fortune in a Master's course in Orthodontics – Master of Science – at the PUSH University in Bonn, which I successfully completed in 2012. At that time, 16 other dentists and I had done our master's thesis on cephalometric features in relation to my facial discrimination level D, which ran from the most anterior attachment point of the earlobe to the lowest attachment point of the nostril. I then published the insights gained from this and considerations on fractal dimensions in the dento-facial area in 2015 (**Fig. D**).

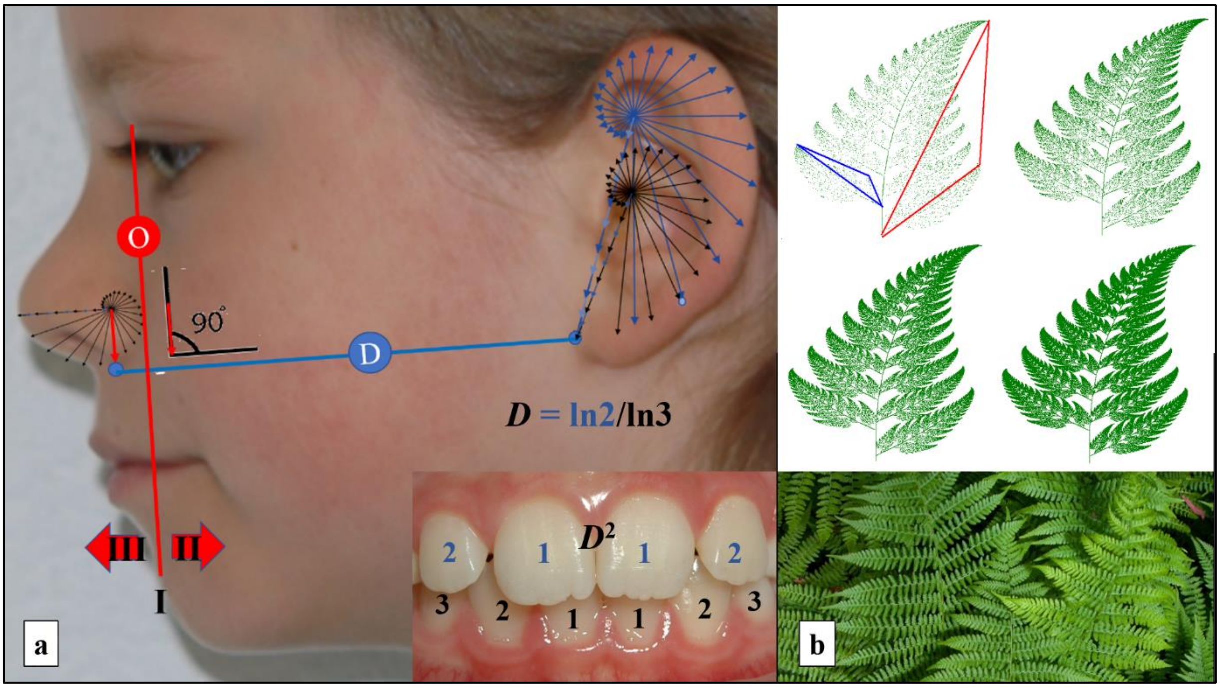


Figure D: *Struction (2015).* (a) shows my 8-year-old son with a first schematic jaw size classification based on an orthogonal O in relation to a facial discrimination plane D [the morphological maxilla]. Patients in whom the orthogonal O ran from the most anterior point of the chin across the most posterior point of the nostril (±1 mm) were assumed to have a moderately sized mandible – called MvB Class I – . In addition, it shows how the mandibular size is related to a facial discrimination plane D [morphological maxilla]. In addition, it shows how the Hausdorff dimension D = ln2/ln3 squared can be objectified at a specific time of anterior tooth change. (b) uses fern leaves as an example to explain the mathematical concepts of "fractals" and "self-similarity" of geometric patterns in natural or artificial entities.

A mathematical ratio found $S = e \cdot D2$ - harmonic relativity - suggested that the ζ4 function present in it – $S = (\zeta4(n=10) + \zeta4(n=11))/2 \approx 1.082$; $D = {}^{\ln 2}/_{\ln 3}$ (Hausdorff dimension; smallest possible fractal); e = Euler's number – can not only be used representatively to compare the growth rates of permanent teeth, but could generally be useful as a reference for estimating growth ratios of all possible fractalsAccording to the fractal theory of VOJTA G. and VOJTA V. (2000, in Teubner-Taschenbuch der statistischen Physik; pp 405-431), the physics of subordinate systems and structure formation belong to the same scientific field. And because the struction spiral matched the position of the equilibrium organ with astonishing precision, I asked myself the fundamental question: Can the ζ4-function, the decimal system and the number 24 represent the gravitational constant numerically (**Fig. E - G**)?

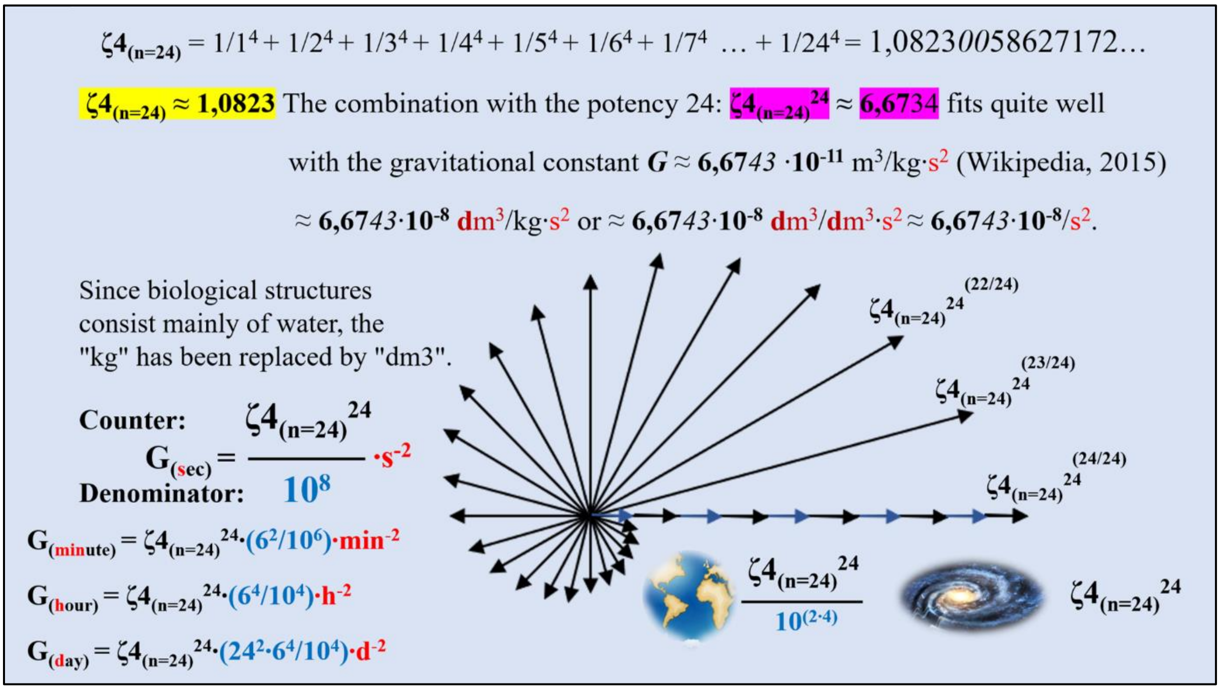


Abbildung E: *The numerical gravitational constant G_n*. The value taken from Wikipedia for G = G_{Wiki} = 6,6743·[$m^3/10^{11}kg·s^2$] contains as numerator the volume (m^3) and as denominator the factor $10^{\mathbf{11}}$ and the mass (Kg) times the time in squared (s^2). If, instead of 1 m^3 , 1000 dm^3 are used because the human body consists mainly of water and 1 dm^3 = 1 kg, then the kg can be reduced. It remains G_{Wiki} ≈ 6,6743/$\mathbf{10^8}$·s^2. If, in a standing human being, the gravitation acting on him is regarded as a stable momentum because his body structure opposes it, then the acceleration (s^2) can be assigned the value 1 (s^2 = 1) or the denominator then only contains the decimal system created from the fingers - 10^8 = $(1+2+3+4)^{(2·4)}$ - as a constant reference. If this reference is omitted because there are no fingers in space, then the following remains $G_{Wiki/n}$ ≈ 6,6743. Since this value already fits quite well with the rounded value of $ζ4_{(n=24)}^{24}$ ≈ 6,6734, from here on the value $ζ4_{(n=24)}^{24}$ is referred to as the numerical gravitational constant $\boldsymbol{G_n}$.

In 2015, it was written in Wikipedia that the given value for G was only certain for the first three digits after the decimal point. I therefore searched for the most recent review of empirically determined values for $\boldsymbol{G_e}$. I found such a paper by S. SCHLAMMINGER, J.H. GRUNDLACH and R.D. NEWMAN in 2015 in the journal PHYSICAL REVIEW D. They presented 21 measured values on G_e from 12 measuring centres. A closer look at this work, however, shows that it contains an annoying methodological error (bias) (**Fig. F**) as well as the structionspiral (ζ4-structionspiral) placed over the ear is superimposed on a numerical image of gravitational waves, then even professors of physics are amazed. (**Fig. G**).

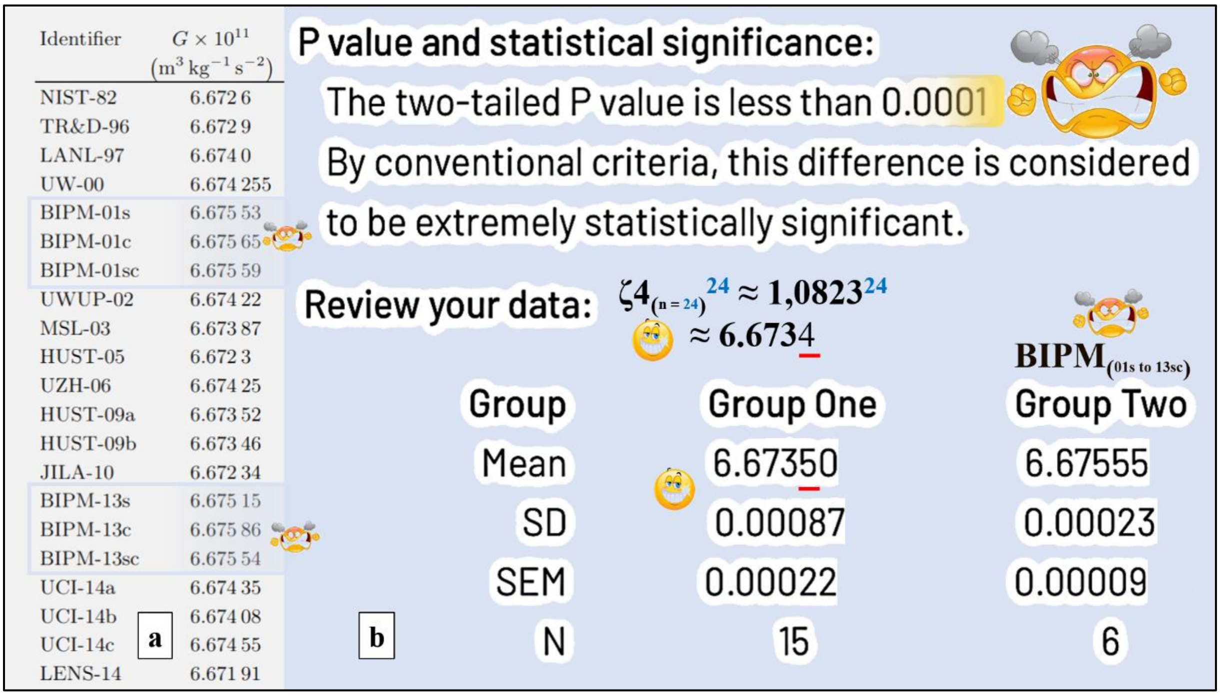


Figure F: *21 evaluated values for the gravitational constant.* (**a**) shows the measured values for Ge collected by Schlaminger et al. (2015) from twelve measuring centres. (**b**) shows a statistical comparison, which proves that the values from the BIPM measuring station differ highly significantly from all others and are therefore to be excluded as "outliers" from the rest of the data pool. Without the values from the BIPM measuring station, the mean value of the empirically determined values μGe ≈ **6.673**(5) fits my calculated value G_n ≈ **6.6734** with excellent reliability.

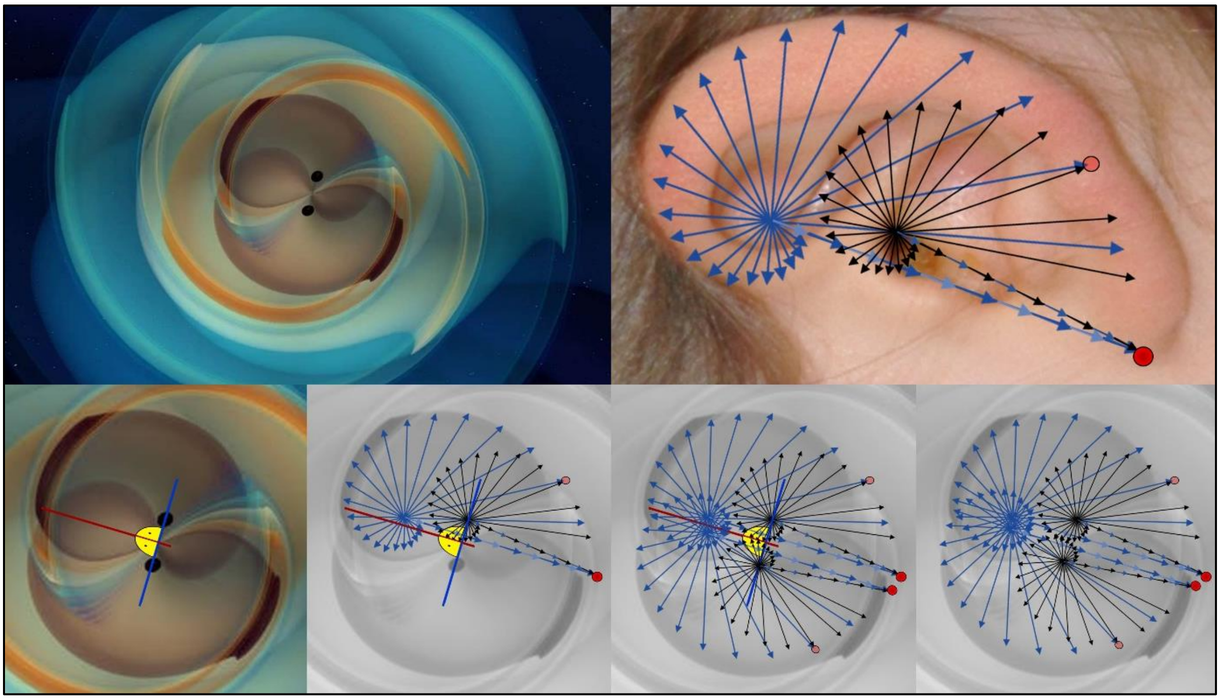


Figure G: *The black hole in the ear.* This figure from Rensselaer Polytechnic Institute numerically shows two orbiting black holes whose gravitational waves match the structionspiral superimposed here in the same way that the superimposition of the structionspiral match my son's anatomical ear structures. The structionspiral of the upper black hole seems to be slightly larger. Are its gravitational waves stronger?

In 2017/18, I recognised how the struction number (S ≈ 1.082) can be used to identify six clustered angles – struction angles – in the cephalometric image and how these can be reliably assigned to three different mandibular sizes – Norma Class II = small; Norma Class I = medium; Norma Class III = large (**Fig. H**).

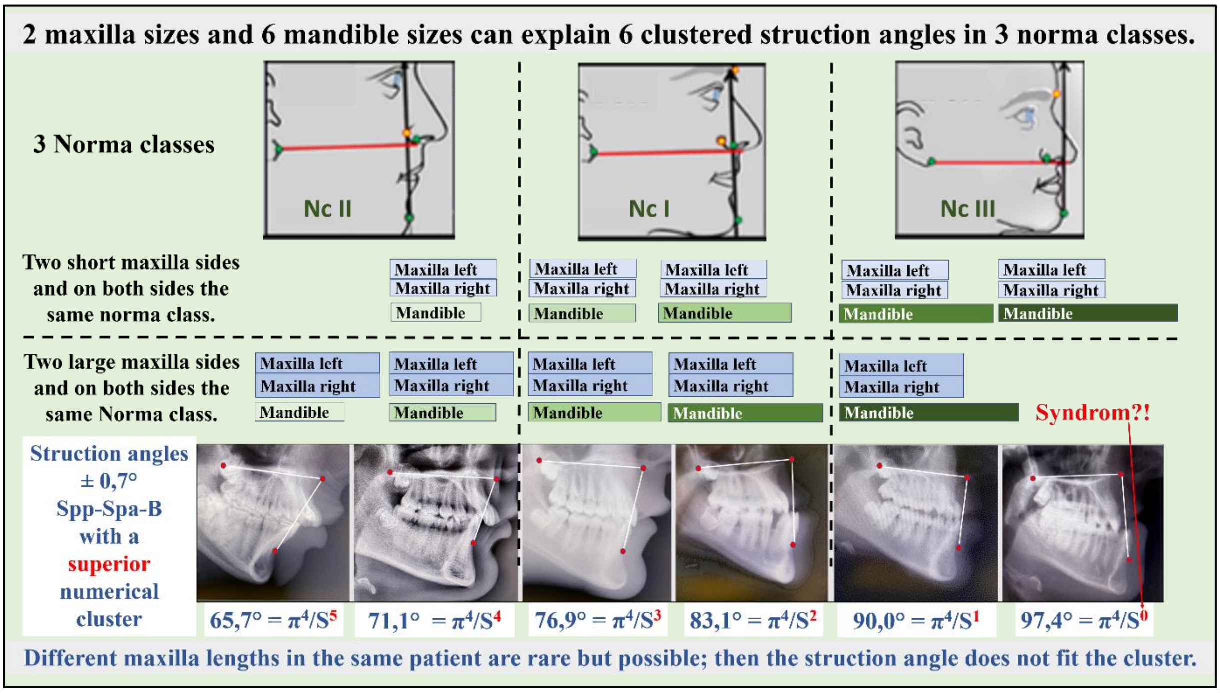


Figure H: *The struction angles.* The figure shows the relationship between a three-part mandibular size classification (Norma classes I, II and III) and five clustered mandibular sizes that can be represented by the ζ4-function.

The discovery that a universal law leads to different occlusions also led, among other things, to the question of the need for treatment of corrective braces: *At what point are dental braces "not necessary", "recommended" or "necessary"*? Since I was repeatedly asked these and other questions during the course of my science studies from 2018 to 2021 at Danube Privat University in Krems, but could not answer them plausibly and easily until after the dissertation, I have answered these and other frequently asked questions in the epilogues on the last pages following the slides on the exam Rigorosum.

The following philosophical dissertation received summa cum laude (according to Wikipedia (2021), this is very rare in dentistry – 2% –). It confirms a premise that has never been questioned for over 70 years and exposes a standard value by W. Bolton (1958) that was falsified by the Second World War and is still used in dentistry today.

Well then; see you in the days to come (x·24) *Martin vom Brocke*

DANUBE PRIVATE UNIVERSITY
Fakultät Medizin/Zahnmedizin

DISSERTATION

Critical appraisal of W. Bolton's standard values in white patients with malocclusions, considering laterality, mandibular size and gender.

„PhD“ for the award of the academic degree
"Doctor of Philosophy",
abbreviated to "PhD „Doctor of Philosophy“

Carried out at the Faculty of Medicine/Dentistry of the Danube Private University

presented by

Dr. med. dent. Martin vom Brocke MSc.

from 4563 Gerlafingen (CH)

.

Supervisor: Univ. Prof. Mag. Dr. Ph.Dr. Willhelm Frank MLS

Dedication to my son Joel Helge:

Thank you, dear Joel,

for allowing me to photograph your dento-facial development for 12 years and use the photos for this work.

TABLE OF CONTENTS

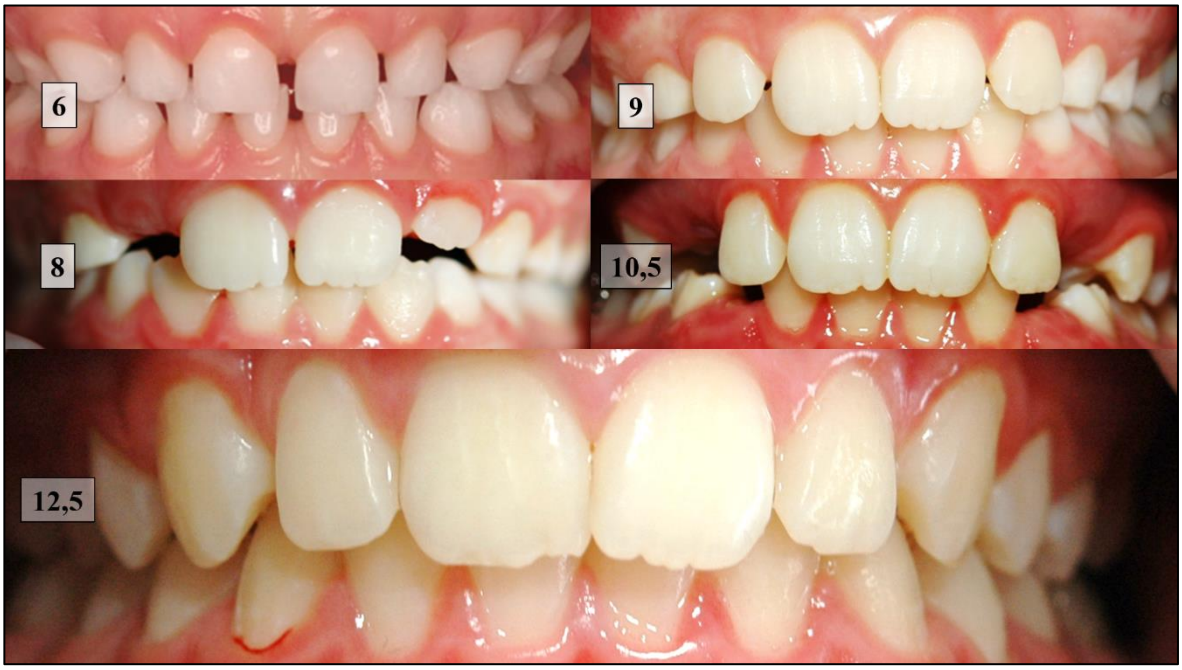
1 INTRODUCTION

1.1 Basic knowledge regarding orthodontics

Orthodontics is a dental discipline that tries to prevent tooth misalignments before they develop, or to correct them if they have already become established. For this reason, orthodontists also need to know how to distinguish between common and uncommon tooth widths [TWs], tooth width sums [TWSs] and intermaxillary tooth width sum ratios [TWSRs].

Distinguishing between common and uncommon TWs, TWSs and TWSRs is relatively trivial during tooth change because of the different tooth colours of deciduous and permanent teeth. However, before and after this, apart from asymmetries or dark spots, there are hardly any clues to be able to recognise unusual TWs, TWSs and TWSRs by means of visual diagnosis alone. During tooth change, knowledge of the eruption times of the permanent teeth with regard to the TWSRs is particularly important in the case of non-attached teeth, because then the deciduous tooth standing above the non-attached tooth is not lost, which in turn leads to an unusual TWSR and thus to unusual occlusion (**Fig. 1**).

Figure 1| Change of teeth between the ages of six and twelve.



Source for Figure 1: The own figure shows one point in time in each of the five different dentition phases during the change of teeth of the author's son: deciduous dentition (6 years); mixed dentition I (8 y.); resting phase (9 y.); mixed dentition II (10.5 y.); permanent dentition (12.5 y.).

Until about the age of six, the human dentition consists of 20 milk teeth. In the mixed dentition phase I [MD I] – at the age of about six to nine years – the incisors are exchanged. This is followed by a resting phase of tooth change for about a year. The mixed dentition phase II [MD II] begins around the age of ten and often ends at the age of twelve, whereby deviations in tooth eruption times of up to two years are still physiological (LEIST, 2005). The eruption of the 12-year molars – 17, 27, 37 and 47 – completes the regular dentition of 28 teeth without the wisdom teeth.

Although laypersons can assess the need for correction of malocclusions on the basis of asymmetries and dark triangles in the anterior region (KLOCKE, 2007), they rarely know the cause(s) of the existing malocclusion(s) and they cannot make a concrete therapy suggestion.

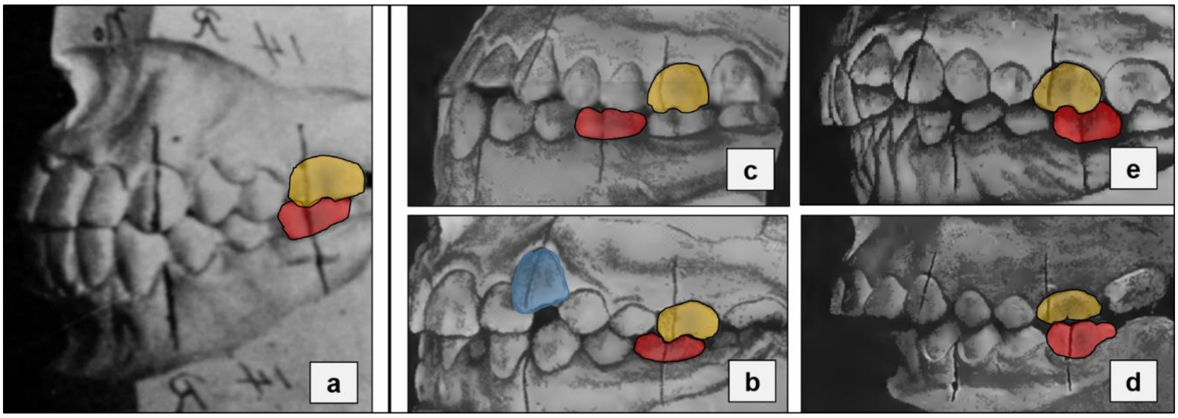
Therefore, it is helpful for building trust with the patient if the orthodontist first formulates only the most conspicuous anterior finding as an anterior diagnosis and addresses possible causes before preparing findings documentation.

Well-known causes of dental malocclusion *directly* caused by the patient are, for example, tongue dysfunction, bottle feeding habits and/or thumb sucking (COZZA ET AL., 2005; FILIPPI ET AL., 2015).

Well-known indirectly acquired causes of malocclusions are, for example, jaw or tooth deformations due to genetic defects, late effects after trauma or deciduous tooth caries, which can manifest themselves in the primary dentition, in MD I, in MD II or only in the permanent dentition (VAN WAES UND STÖCKLI, 2001).

The orthodontic therapy suggestion resulting from the findings documents is usually based on the cause and the resulting diagnosis of "malocclusion", which can deviate to varying degrees from the "normocclusion" according to E.H. ANGLE from 1899 (ANGLE, 1899, 1906, 1907). "Malocclusion" is diagnosed when the mesio-buccal cusp of the first molar in the upper jaw [M_1] lies above the buccal fissure of the first molar in the lower jaw [m_1] [Angle class I = normocclusion] and at the same time there is a disturbance of the tooth alignments, or an Angle class II/1 or II/2 [two different distal bite variants] or an Angle class III [mesial bite]. In the mesial bite, the buccal fissure of m_1 is mesial and in the distal bites, it is distal to the mesio-buccal cusp of M_1 (**Fig. 2**).

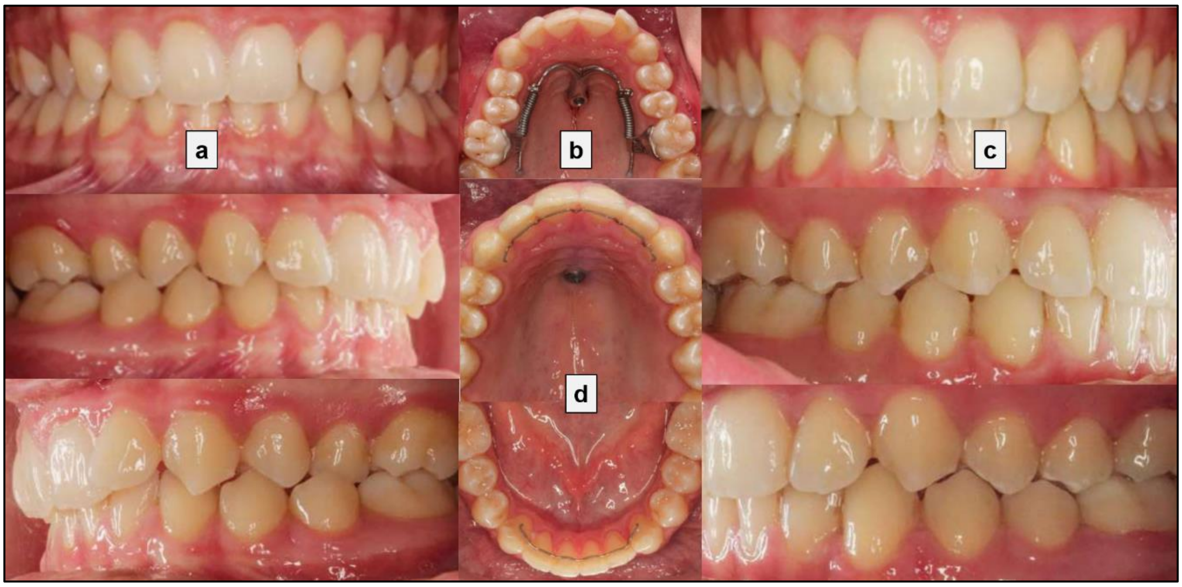
Figure 2| Normocclusion and the malocclusion according to ANGLE (1899).



Sources for Figure 2: Figures (**a**) to (**e**) from ANGLE (1906 (**a**); 1907 (**b** to **e**)) - here supplemented in colour - describe his "three-part" bite classification in relation to the first upper molar [M_1]. He recommended M_1 as a reference for the sagittal position of the mandibular arch. Thus, with M_1 in relation to the mandibular first molar [m_1], a normocclusion [Angle Class I] results when the mesio-buccal cusp of M_1 covers the mesio-buccal fissure of m1 and at the same time there is no malocclusion (**a**). Figure (**b**) shows a Class I malocclusion with an ectopic canine 23. Figure (**c**) shows a Class III malocclusion. Figure (**d**) shows an Angle Class II/1 or Figure (**e**) shows an Angle Class II/2.

The borders between the angle classes are not defined more precisely, which is why there are authors who also speak of a tendency towards an angle class – e.g.: A tendential Angle Class II – (SCHÄTZLE ET AL., 2020) (**Fig. 3**).

Figure 3| A frontal deep bite with a tending Angle Class II.

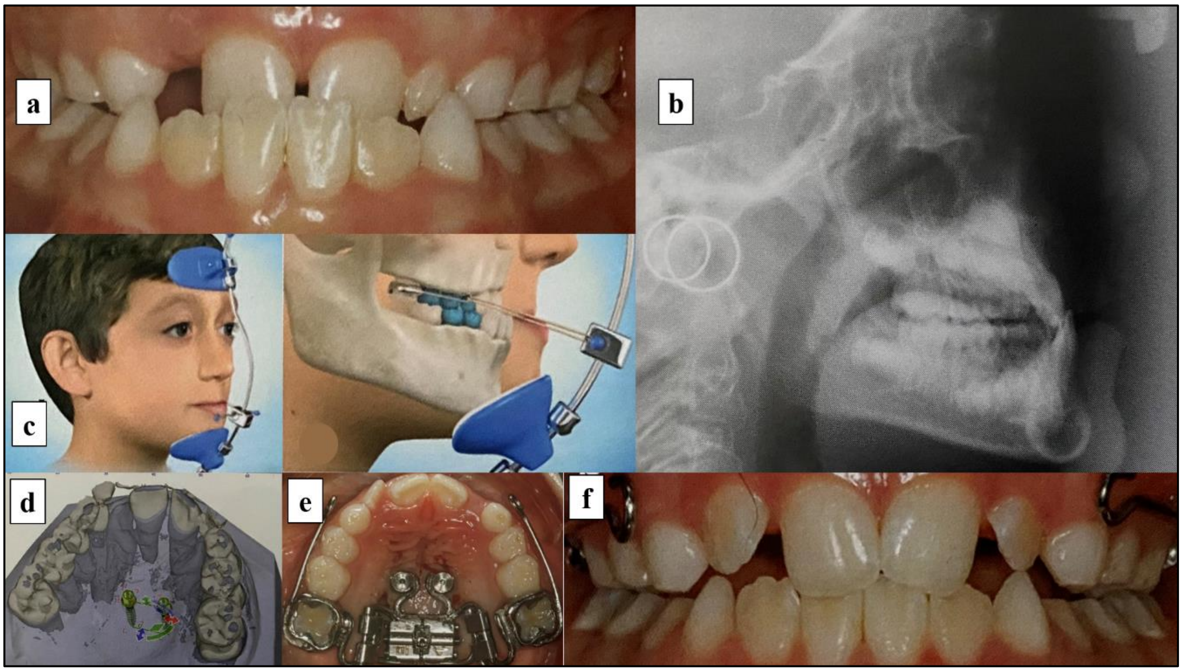


Source for Figure 3: Figures (**a**) to (**d**) from SCHÄTZLE ET AL. (2020) show with figure (**a**) a pre-therapeutic deep bite in combination with a tending Angle Class II. Figure (**b**) shows the appliance used to distalise the maxillary posterior teeth with a palatal implant anchorage. Figure (**c**) shows the post-therapeutic anterior result and the resolved crossbite in the region of the second premolars. Figure (**d**) shows two fixed orthodontic retainers to stabilise lifetime the outcome of the front teeth.

Other authors help themselves in terms of the precision of the Angle classification by adding a cephalometric image [FR image] to describe the occlusal situation and then speak of a bite position I, II or III according to Angle (SCHNABEL ET AL., 2016a; SCHNABEL ET AL., 2016b), although the first FR devices only became known in orthodontics after 1931 and thus after the death of E.H. ANGLE († 11 August 1930, USA) (HOFRATH, 1931; BROADBENT, 1931).

Still other authors refine the Angle classification by choosing a formulation for the diagnosis such as "... *a class ¼ pm mesial interlocking in the molars*.... (PAZERA, 2020)"; where pm means premolar width (**Fig. 4**).

<u>Figure 4l</u> A frontal crossbite with a ¼ Pb mesial interlocking of the molars.

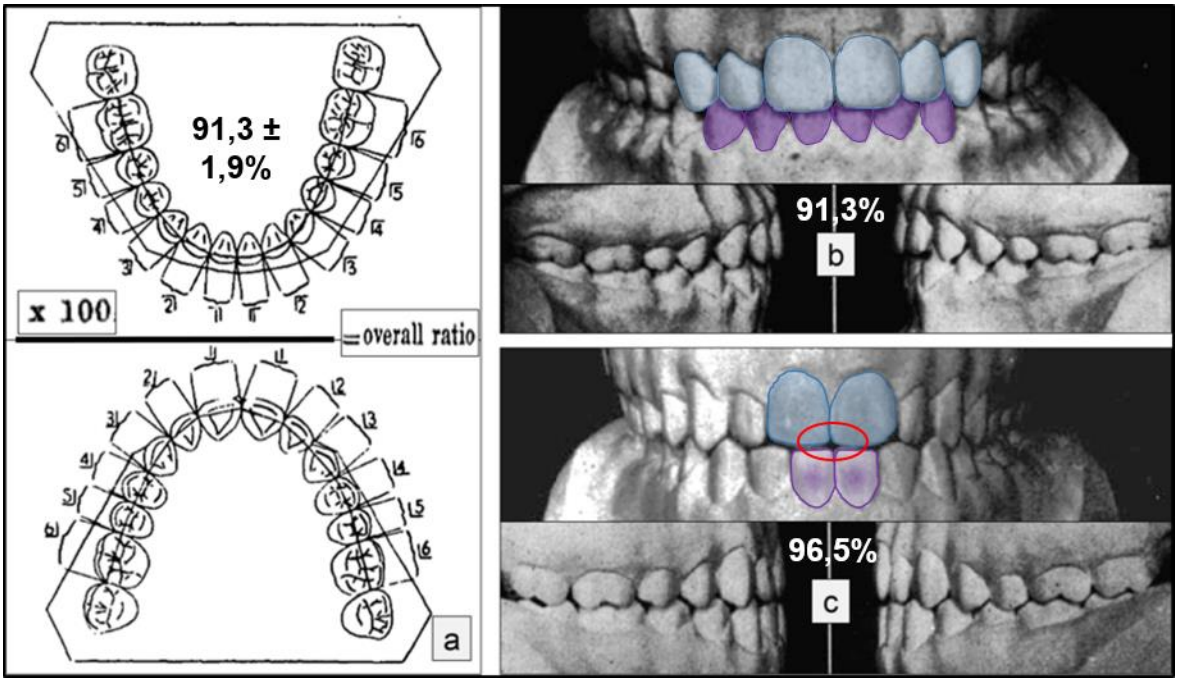


Source for Figure 4: Figures (**a**) to (**f**) from PAZERA (2020) shows with figure (**a**) the pre-therapeutic frontal crossbite in an eight-year-old boy. Figure (**b**) shows his Cephalometric image. Figure (**c**) shows the treatment principle with a Delaire mask/reverse headgear appliance. The aim of this appliance is to shift the child's upper jaw base mesially and at the same time to inhibit the growth of the lower jaw. Figure (**d**) shows a DVT/DICOM data set which was virtually overlaid with a maxillary STL-SCAN for position planning of the mini-screws anchored in the palate. Figure (**e**) shows the Headgear appliance in situ. Figure (**f**) shows the corrected crossbite after advancing the maxillary dentition by ¼ premolar width. It is unclear which premolars are meant here.

1.2 BOLTONs Normvalues

In 1958 WAYNE BOLTON drew attention to the fact that malocclusions with unusually large or small TWSRs - he called such TWSRs: "disharmonic" - could no longer be easily converted into a normocclusion. In order to have norm values and confidence intervals for "harmonic" intermaxillary anterior TWSR one hundred times the lower anterior TWS divided by the upper anterior TWS he called the Anterior Ratio [AR]; his mean AR was AR_{μ} = 77.2% ± 1.7%. One hundred times the lower total TWS divided by the upper total TWS he called the Overall Ratio [OR]; his mean OR was OR_{μ} = 91.3% ± 1.9% (**Fig. 5**).

<u>Figure 5|</u> Mean [µ] and the first standard deviation of BOLTON's OR.



Source for Figure 5: Figures (**a**) to (**c**) from BOLTON (1958) - supplemented here in colour - show with Figure (**a**) the calculation principle of the overall ratio [OR] from the lower total TWS divided by the upper total TWS. He calculated a mean value [norm value] of ORµ = 91.3% for the OR. His first standard deviation was ± 1.9%, resulting in a confidence interval of 87.5% to 95.1%. Figure (**b**) shows a harmonious TWSR Figure (**c**) shows a disharmonious TWSR of the first twelve permanent teeth with an OR of 96.5%. Here, a head bite of the lateral incisors and a small vertical open bite of the central incisors were present after the teeth were placed in an Angle Class I.

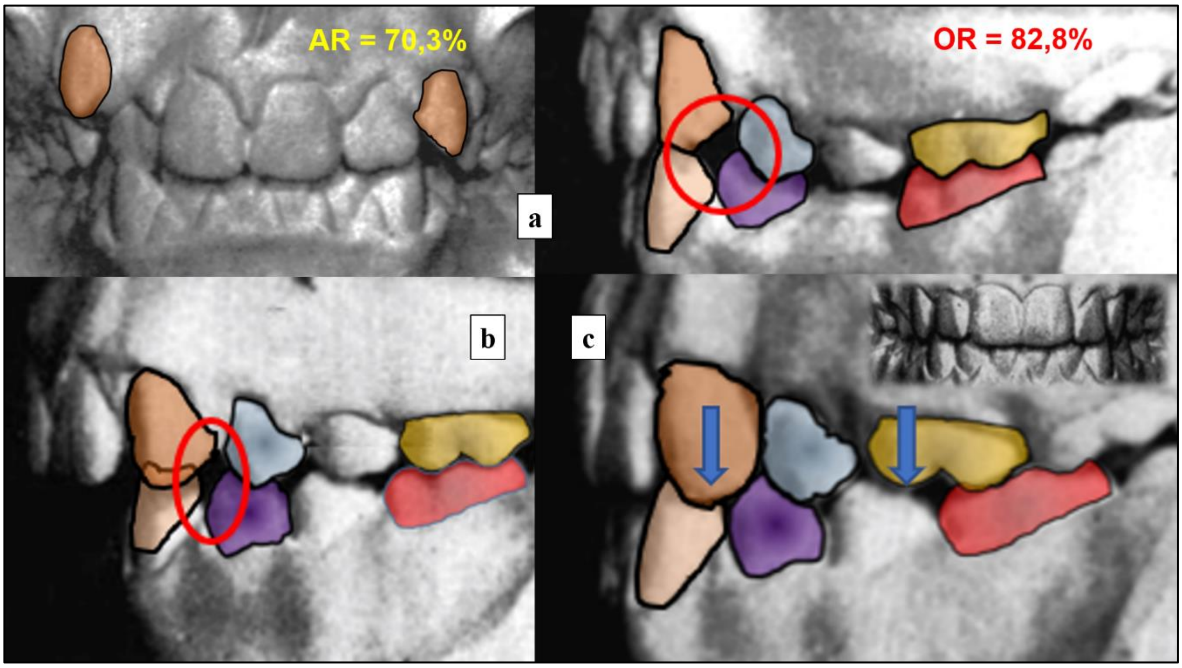
Whether the first or the second standard deviation of BOLTON's AR and OR is of greater clinical significance is unclear, because accredited authors are at variance on this:

Some orthodontists are of the opinion that the first standard deviation for the OR (± 1.9% ≈ ± 0.9 mm ZBS discrepancy between the maxillary TWS and mandibular TWS) determined by BOLTON 1958 is already sufficient as a diagnostic limit for "disharmonious TWSR" (BOLTON, 1962; ARAUJO AND SOUKI, 2003; AKAYALCIN ET AL., 2006; OTHMAN AND HARRADINE, 2007).

Other orthodontists, however, find that from a clinical point of view, the diagnosis of " disharmonic TWSR" should rather be made only from the second standard deviation for the OR (± 3.8%, ≈ ± 1.8 mm ZBS discrepancy between the maxillary TWS and mandibular TWS) (CROSBY AND ALEXANDER, 1989; FREEMAN ET AL., 1996; SANTORO ET AL., 2000; UYSAL ET AL., 2005; ENDO ET AL. 2008).

Using case presentations, BOLTON (1958) demonstrated how it is practically impossible to establish normocclusion in the presence of too large a TWSRs (see Fig. 5c) or too small a TWSRs (see the following example, Fig. 6). For example, one of his patients had a reduced OR of 82.8% and a reduced AR of 70.3% – the lower limits of his confidence interval were 87.5% for the OR and 73.8% for the AR –. In this patient, the first thing he did was to set an Angle Class I on the molars and then level the alignment. In principle, normal occlusion would now be achieved if the canine teeth were also reliable. At that time, BOLTON assumed in the sense of a latent premise that the lower ZBSn varied more frequently than the upper ZBSn (numerator = variable; denominator = constant), which is why for him – as is assumed here – the cause of the remaining overjet [OJ] must have been the too small lower teeth. He corrected the OJ compensatorily by extracting the second premolars in the upper jaw and then closing the gap by mesialisation of the first upper molars and distalisation of the first upper premolars and the upper front teeth. The result was supported front teeth and no dark gaps in the visible area. Even if such a result corresponds to an Angle Class II due to the occlusion of the molars and is therefore still called malocclusion in principle, at least the canines were in an Angle Class I in this case presentation and there was an aesthetically pleasing result (**Fig. 6**).

Figure 6l A case presentation by BOLTON (1958) with a too small AR and a to small OR.



Source for Figure 6: Figures (**a**) to (**c**) from BOLTON (1958) - here supplemented in colour - show with figure (**a**) the initial models of a permanent dentition with ectopic upper canines as anterior diagnosis and disharmonious TWSRs - AR = 70.3% as well as OR = 82.8% - as well as an Angle Class I in the region of the first molars. Figure (**b**) shows the intermediate models after correction and straightening of the alignments in the maxilla and mandible as well as dark "triangles" in the visible area distal to the canines (circled in red). Again, only the first molars and not also the canines are in an Angle Class I. Figure (**c**) shows the final models with status after extraction of the maxillary second premolars and gap closure. The result was an Angle Class I in the canine region but an Angle Class II in the molar region as well as a pleasing anterior situation with "harmonised" TWSRs.

To the best of our knowledge, it is not known why BOLTON hardly made any more detailed comments on the Posterior Ratio [PR] (PR = hundred times the lower side TWS divided by the upper side TWS) and the question arises: What if orthodontic therapy suggestions were better guided by the separately determined values for the AR and the PR and not by the OR?

This critical question may be asked because numerical examples can prove that the value for the OR cannot be calculated directly from the values for the AR and PR:

$$\text{The OR} \neq (\text{AR} + \text{PR}).$$

In addition to this uncertainty based on a mathematical fact, six further uncertainties [information gaps = uncertainty factors] can be identified in BOLTON's study (1958), which could falsify his mean values for the AR and OR or be biases – biases are hidden methodological errors (PANDIS, 2014) –. For the literary evidence, see chapter 1.3.

Firstly: it remained uncertain whether all patients had been of the same collective identity or heritage: The Ethnicity as a factor of uncertainty.

Secondly: It remained uncertain whether there had been lateral differences in the dentures of his patients, which possibly compensated for each other: The Laterality as a factor of uncertainty.

Thirdly: It remained uncertain whether the patients in his examination pool had lower TWSs of any size, because it could be that he had mainly examined plaster models of patients with a very specific size of lower TWSs: The mandibular tooth width sum as a factor of uncertainty.

Fourthly: It remained uncertain how many women or men had been in BOLTON's patient pool: The gender distribution as a factor of uncertainty.

Fifthly: It remained uncertain whether his natural normocclusions standing in a compensation curve (OR_{μ} = 91.1%; AR_{μ} = 77.6%) and his therapeutically straightened normocclusions (the mean values [µ] for these OR and for these AR had not been given by BOLTON) only happened to have different OR or AR in relation to the total patient pool (OR_{μ} = 91.3%; AR_{μ} = 77.2%). The compensation curve as an uncertainty factor.

Sixthly: It remained uncertain whether BOLTON's method of measuring tooth widths by means of dividers was also reliable, because he had not made a measurement error analysis. The tooth width measurement method as a factor of uncertainty.

Despite the existing uncertainty factors, BOLTON's analysis is still clinically relevant today because recognised authors recommend that patients be educated pre-therapeutically regarding any TWSs discrepancy that may be present (PROFFIT AND ACKERMANN, 1986; FREEMAN ET AL., 1996; ALKOFIDE AND HASHIM, 2002; OTHMAN AND HARRADINE, 2007).

1.3 BOLTONs Uncertainty factors

This chapter looks in more detail at the current knowledge about the six above-mentioned uncertainty factors in BOLTON's study and why they might be selection bias and/or measurement bias.

1.3.1 On ethnicity

It has been known for several decades that TWRs can differ regionally (BAILIT, 1975). And there are also studies comparing TWRs with the presence of all three Angle classes. For example, in this regard, NIE AND LIN (1999) revealed a mean AR_{μ} of 81.5% and a mean OR_{μ} of 93.3% in 300 Chinese patients with an Angle Class I, II or III.

There are now many studies with ethnically different data pools, such as patients from Saudi Arabian (ALKOFIDE AND HASHIM, 2002), Peruvian (BERNABÉ ET AL., 2004) or Swedish (REDAHAM AND LAGERSTRÖM, 2004) populations, which show significant differences from BOLTON's norm values.

It is conceivable that ethnic skin type could also be a discriminating factor in terms of TWSRs: for example, the ORs of Whites (OR_{μ} = 92.3%) differ significantly from Hispanics (OR_{μ} = 93.1%) and Blacks (OR_{μ} = 93.4%) (SMITH ET AL., 2000) (**Fig. 7**).

Figure 7| Three well-known politicians with different ethnic skin colours.

Sources for Figure 7: The illustrations taken from Wikipedia shows with figure (**a**) Donald Trump (President of the USA from 2017 to 2021) as a representative of the white population. He has – as is assumed here – optimised his TWSRs by means of prosthetic crowns or veneers. Figure (**b**) presents Alexandria Ocasio-Cortez (youngest member of the US House of Representatives since 2019) as a representative of the Hispanic population. Figure (**c**) presents Barak Obama (President of the USA from 2009 to 2017) as a representative of the black population.

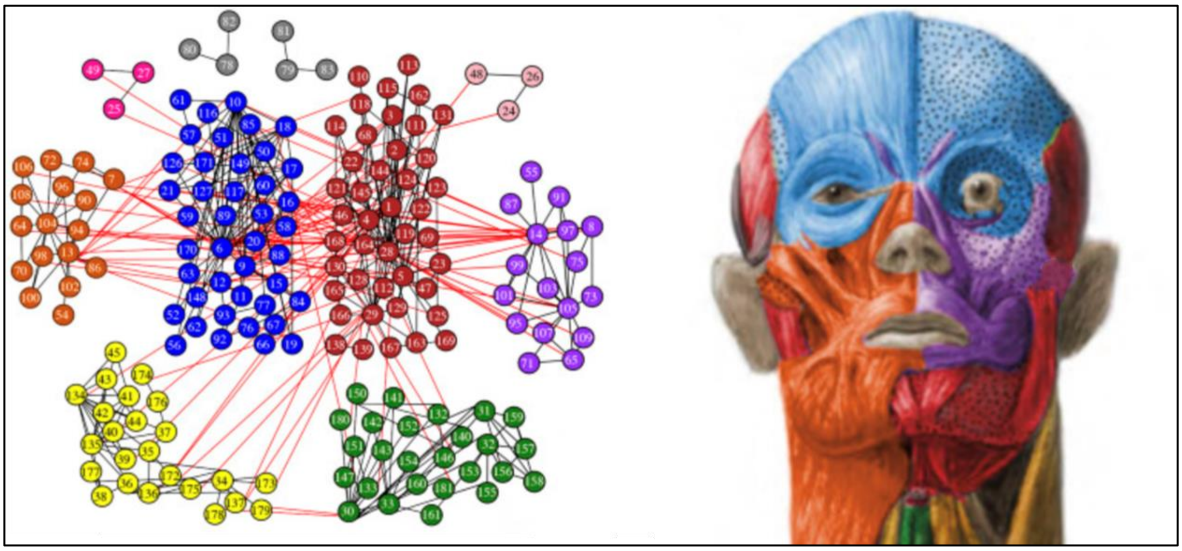
Although SMITH ET AL. (2000) used the discriminatory criterion of skin colour to reveal differences in the ZBSVs, they had not mentioned anything in relation to ethnically different jaw relations. These could possibly have been distinguished – as is assumed here – with the cephalometric analyses used since 1931.

In terms of comparisons between facial profile analyses and their TWSRs, to the best of our knowledge there are no published standard values. This may be because the usability of facial reference points has only been studied more intensively for a few years. For example, the practical measurement accuracy of the points "Glabella [Gl]" – most prominent forehead point between the eyebrows –, the "Soft tissue Pogonion [Pg']" – most anterior chin point – or the "Alara posterior [Ap]" – most posterior point of the nostril contour – is ± 1mm (BAYSAL ET AL., 2016).

1.3.2 On laterality

It is hard to imagine that malocclusions can influence the TWSRs (CROSPY AND ALEXANDER, 1989). But it is theoretically conceivable (a thought experiment) that unusual TWs could lead to a laterally different malocclusion if the TWs correlate with the size of their skeletal bases. This would at least be plausibly possible because the maxilla originates from two gene pools and the mandible from one gene pool (ESTEVE-ALTAVA ET AL., 2015) (**Abb. 8**).

Figure 8| Ten musculo-skeletal modules of facial development.



Source for Figure 8: The figure from ESTEVE-ALTAVA ET AL. (2015) shows schematically that there are ten musculo-skeletal modules in the head region, which are structured from ten different gene pools, which allows an evolutionary head modification. For example, the first musculo-skeletal module includes: Os hyoideum, malleus, mandibula, Os occipitale, Os parietale, Os temporale and most of the masticatory muscles (including the tongue muscles). The second musculo-skeletal module includes: Os ethmoidale, Os frontale, Os lacrimale, Os nasale, Os palatinum, Os sphenoidale, the Conchea nasales, the vomer, the periauricular muscles and the muscles that support the swallowing function. The fifth musculo-skeletal module includes the left side of the maxilla, the left os zygomaticum and most of the left mimic muscles. The sixth musculo-skeletal module includes the right side of the maxilla, the right os zygomaticum and most of the right mimic musculature.

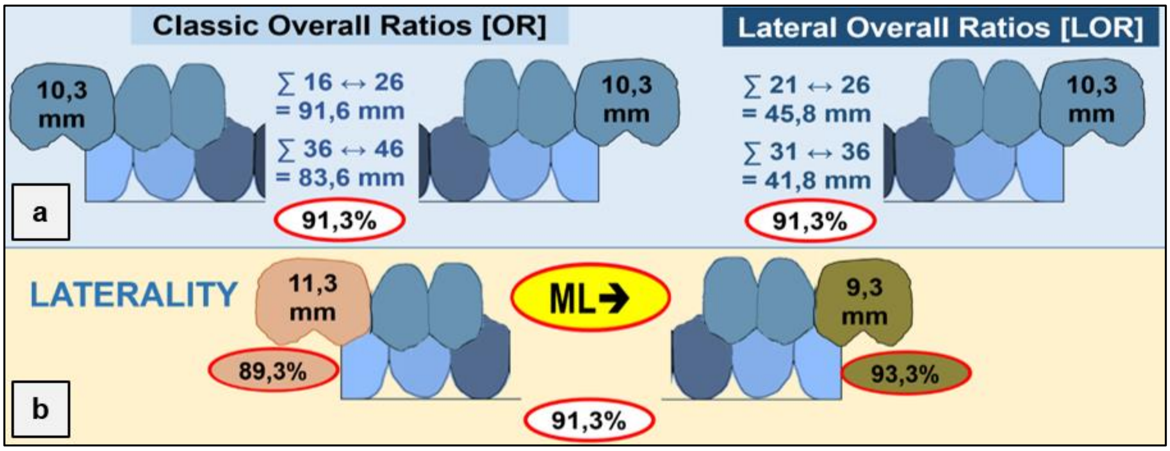
Or less plausibly, as with eye colour, it could theoretically be the case that tooth widths, independent of their skeletal bases and/or lateral affiliation, could be genetically laid out in such a way that they can be transmitted from different parents or even grandparents, leading to malocclusion in the case of mixed transmission of the TWSs.

Playful theoretical reasoning about such occlusionally unfavourable lateral variability of tooth width ratios caused by heredity is allowed, but it does not represent evidence-based knowledge that can be used for treatment strategies, because it needs a data-based background for reliable therapy suggestions. (GIANELLY, 2000; PROFFIT, 2000; TÜRP UND ANTES, 2001).

The basal supporting bones of the brain, such as the skull bases, but also the walls of the orbits, nasal cavities, auditory canal walls, etc., develop from cartilaginous pre-structures which, together with neural and vascular structures, are positioned in a genetically determined manner and which are later replaced or supplemented – except for the anterior parts of the nose – by replacement and covering bones (KAHLE ET AL., 1990; FRICK ET AL., 1992). In this process, the development of the head and the development of the body take place with different priority (FRICK ET AL., 1992) and the oral cavity as the border area between the head and the body must be positioned in such a temporally coordinated way that it is not deformed by the different growth patterns of the head modules, because otherwise – as is assumed here – its function would be negatively influenced. However, using such assumptions as a basis for therapy seems rather daring and should only be done with the clear consent of the patient.

BOLTON had discussed the problem of lateral differences in 1962, but never adapted his analysis accordingly. Therefore, the uncertainty factor "lateral differences" [laterality] remained in his method, which has hardly been investigated in the literature until no – BOLTON's normal value – calculated from mirrored TWs, the two lateral ORs [LORs] are also 91.3% (**Fig. 9a**). If, to illustrate the relevance of laterality, the TW of tooth 16 is enlarged by one millimetre and the TW of tooth 26 is reduced by one millimetre, the OR of 91.3% remains, although a LOR_r of 89.3% on the right and a LOR_l of 93.3% on the left is produced. In practice, a lateral dominance in the form of a midline shift to the left in the maxilla occurs, which cannot be predicted with the classical method of BOLTON (1958) for calculating the OR (**Fig. 9b**).

Figure 9| Example of the relevance of laterality using the overall ratio as an example.

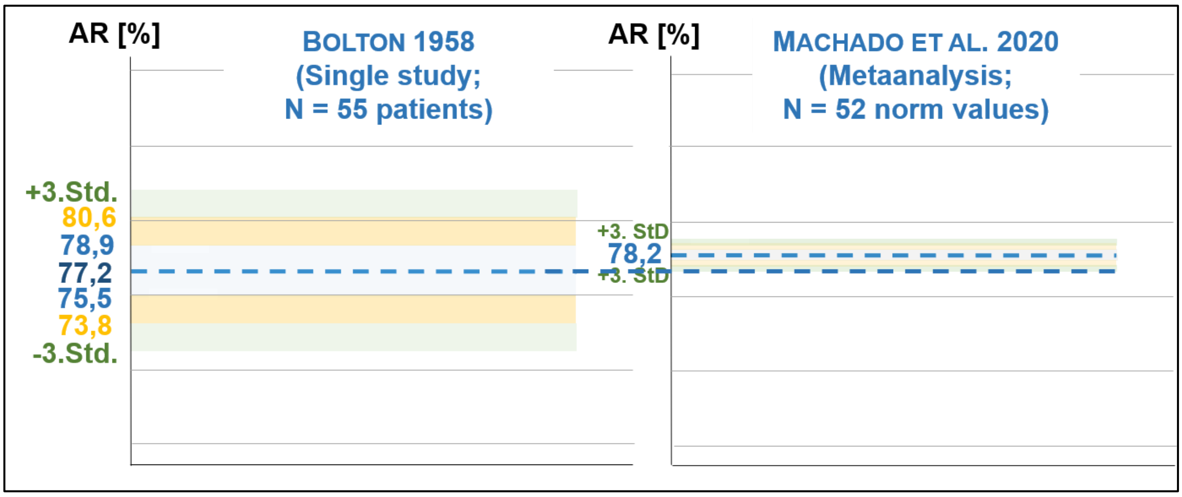


Source for figure 9: The own figure (a) shows an example of an OR of 91.3% from mirrored TWs and the left lateral overall ratio [LOR], which is also 91.3%. The own figure (b) schematically illustrates the development of laterality after an opposite TWs change by one millimetre of teeth 16 and 26 and a resulting midline shift (ML) to the left.

1.3.3 On the mandibular tooth width sum

BOLTON's choice of formula (numerator = variable / denominator = constant) assumes that the different TWSRs are primarily due to more variable TWSs in the mandible. In 2020, a first meta-analysis of 52 comparative studies to Bolton's analysis was published (MACHADO ET AL. 2020), which concluded that patients with a natural normocclusion have an AR of ARµ = 78.24 ± 0.20% or an OR of ORµ = 91.74 ± 0.18% when considered globally in a pooled perspective, and these values are higher than the mean values of BOLTON (1958). BOLTON had reported a mean AR of ARµ = 77.6% for his eleven untreated cases with excellent normocclusion and an AR of ARµ = 77.2% for all 55 patients. In the meta-analysis by MACHADO ET AL. (2020) on AR, the range between the third standard deviations – 99.7% of the 52 integrated studies (virtually all) – was 77.65% to 78.83%. Thus, in comparison, BOLTONs mean value for ARµ = 77.2% (77.6%) is below the range of values by MACHADO ET AL. (2020), which is probably why BOLTON (1958) had a majority of patients with relatively small lower TWSR's in the study pool (**Fig. 10**).

Abbildung 10l A comparison of data from BOLTON (1958) with MACHADO ET AL. (2020).



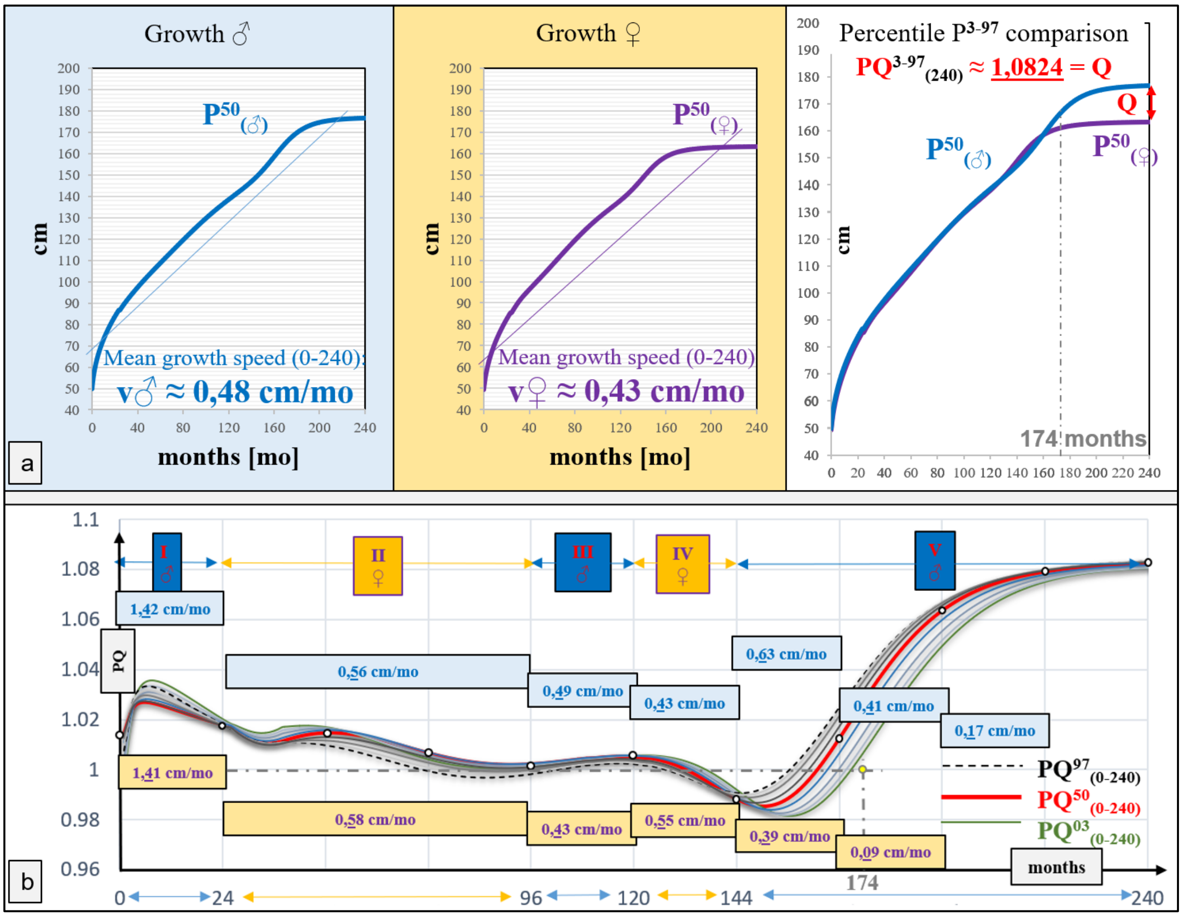
Source for Figure 10: The own figure schematically shows the data distribution for the ARs in the case of BOLTON's (1958) study compared with the meta-analysis of MACHADO ET AL. (2020). BOLTON's mean is below the third standard deviation of MACHADO ET AL.

From a completely plausible point of view, the mandibular tooth width sums would also have to coincide with the mandibular size: E.g., relatively small mandibles would also have to have relatively small tooth width sums. Problem: *To date, it has not been determined how relative mandibular sizes can be easily objectified clinically.*

1.3.4 On gender distribution

Significant differences in TWSR's can also be revealed when comparing the sexes (LAVELLE, 1972; SMITH ET AL., 2000), if - as assumed here - the number of cases is correspondingly high. Meta-analyses such as the US body-growth study by KUCZMARSKI ET AL. (2002) show that structural size differences in the sexes are very likely. Their growth percentiles are used, among other things, for estimating growth potential, in order to be able to estimate the period of increased body growth advantageously for the therapy principle of functional orthodontics - concept of influenced growth promotion (BACCETTI ET AL., 2002; DIETZ-MAGEL, 2008; DIBIASE ET AL., 2015), whereby the growth rates in the sexes differ depending on the age period and it is therefore conceivable that cephalometric characteristics such as the TWS-R's could also differ in the sexes (**Fig. 11**).

Figure 11| A two-year interval interpretation of U.S. growth percentiles.

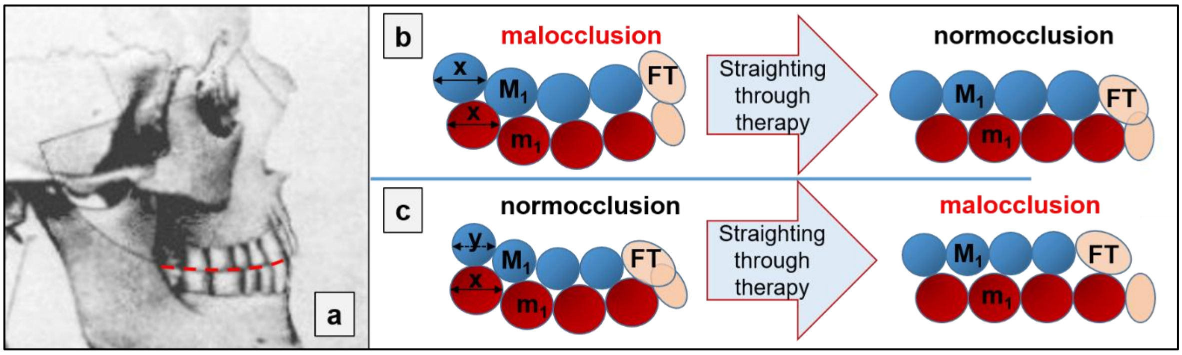


Source for Figure 11: The own figure (**a**) shows the growth percentiles and quotients [PQ; male/female] calculated from the data of KUCZMARSKI ET AL. (2002). For example, males are 94% likely to grow taller than females by PQ Q ≈ 1.0824. Figure (**b**) shows that 14½-year-old boys (174 months) are usually taller (PQ >1) than 14½-year-old girls.

1.3.5 On the compensation curve

Another problem of BOLTON's analysis is the interpretability of his results, because his data pool included 44 study models with therapeutically created normocclusion, of which it is not known to what extent the treatments carried out were uniform and whether patients with a straightened occlusion and normocclusion created in this way just happen to have different ZBSVs than patients whose normocclusion is positioned in a natural spee (SPEE ET AL., 1890) / or compensation curve (ORTHLIEB, 1997). The spee curve is a natural phenomenon observable in the sagittal view of the mandible with an arcuate arrangement of the teeth, with the maxillary posterior teeth convexly oriented caudally and the mandibular teeth concavely oriented cranially (SPEE ET AL., 1890). The area on the spee curve between the buccal cusp of the most posterior lower molar and the incisal edge of the lower middle incisor is called the sagittal compensation curve (ORTHLIEB, 1997; SHANNON and NANDA, 2004) (**Fig. 12a**).

Figure 12| A straightened malocclusion can become a normocclusion and vice versa.

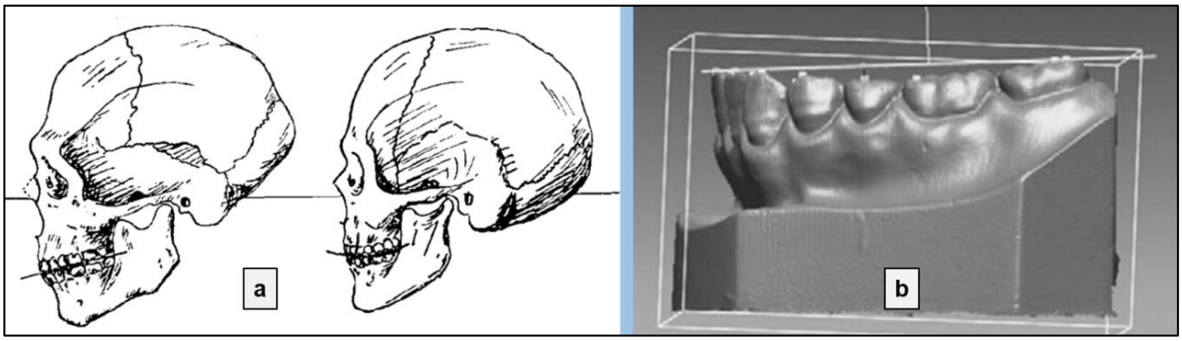


Sources for Figure 12: Figure (**a**) from SPEE ET AL. (1890) shows the spee curve, which can be described as an arcuate tooth positioning phenomenon. The red dashed part marks the region in the tooth area, which is called the compensation curve in some works (ORTHLIEB, 1997; SHANNON and NANDA, 2004). The own figure (**b**) shows schematically how a normocclusion can be achieved by straightening the compensation curve of posterior teeth of equal width that are in intermaxillary malocclusion - shown here as spheres. Figure (**c**) shows what can happen to posterior teeth in normocclusion when the upper teeth - here smaller spheres - are narrower than the lower teeth and the compensation curve is straightened: Here, the straightening of the compensation curve results in malocclusion. In both results - (**b**) and (**c**) - the lower front teeth (FT) are more proclined than before the compensation curve was straightened.

SHANNON and NANDA revealed in 2004 that the flattening of the compensation curve caused by an orthodontic appliance is partly due to the eruption of the mandibular premolars and PANDIS ET AL. specified in 2010 that the flattening effect is mainly due to the proclination of the lower incisors (**Figs. 12b and 12c**). PANDIS ET AL. also concluded in 2010 that it would be advisable to conduct studies on the flattening of the spear curve in different facial profiles and its effect on mandibular rotation.

It seems as if PANDIS ET AL. (2010) with this conclusion possibly also wanted to allude to works such as those of ANDRIK from 1963 and 1967. ANDRIK suggested at that time - without wanting to or being able to proclaim a regularity - that the expression of the Spee curve and the increase in tooth misalignments over many thousands of years could be the result of a change in the skull of humans (**Fig. 13**).

Figure 13| An anthropological assumption about the origin of the compensation curve.



Sources for Figure 13: Figure (a) from ANDRIK (1963) with image transfer from SCHURICHT (1952) illustrates the reduction phenomena in the human jaw region that accompany the development of the spee curve. Figure (b) from CHEON ET AL. (2008) illustrates the compensation curve of one of their patients in relation to the occlusal plane. It was on average 1.6 mm deep at its most concave point - in the region of the 2nd premolars.

CHEON ET AL. (2008) revealed a confidence interval for the extent of the compensation curve depth - tip of the 2nd premolar to the occlusal plane - of 0.1 mm to 3.1 mm and that this distance is greater the more posteriorly the mandible is positioned in relation to the skull base.

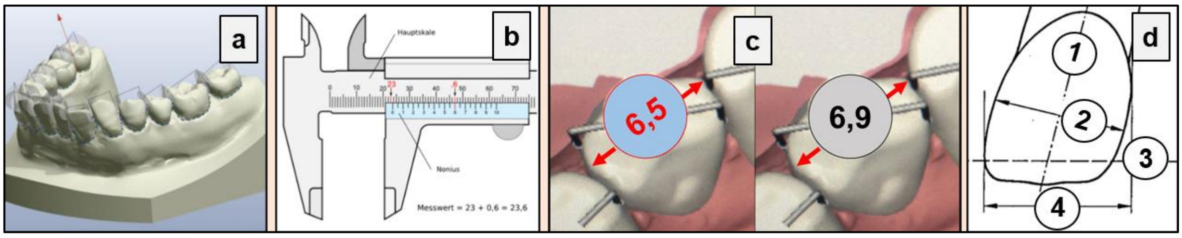
In relation to the angle classes, it was shown that the compensation curve is significantly more pronounced in patients with a class II than in patients with a class I (AL-SARAF ET AL., 2010; GÜLSILAY AND HÜSAMETTIN, 2018). AL-SARAF ET AL. 2010 found no significant difference in the depth of the compensation curve when comparing the sexes.

Because the therapy principles made in BOLTON's pool are not known, the influence of different compensation curves cannot be estimated.

1.3.6 Zur Zahnbreitenmessmethode

In the end, the uncertainty also remains as to how reliable BOLTON's method of measuring the width of teeth by using a divider was. He had not made any measurement error analysis and there are hardly any studies which could repeat his methodology in a reliable way. A master thesis by ALAMIR (2013) can be found on the Internet, which is quite close to the work of BOLTON, but it also did not perform a measurement error analysis. Among other things, ALAMIR reviewed the OR in 2013 using 52 plaster models of completed cases that had been recognised by the American Board of Orthodontics [ABO] as having the highest qualification for an Angle Class I type orthodontic result in the first molar region. ALAMIR revealed a result regarding ORµ (= 91.3% ± 1.8%) which possibly only by chance matched the result of BOLTON very well. It is mainly "grey literature" - literature not published by a publisher - which proves that the possibility should be taken into account that in terms of tooth width measurement, insufficient measurement accuracy could also be a bias which could have an influence on the calculation of CVS, because seriously done research work is also characterised by a measurement error analysis (ULBRICH, 2016; VON DER WENSE 2013) (**Fig. 14**).

Figure 14| Four examples of possible bias in the case of tooth width measurements.



Sources for Figure 14: Figure (**a**) from ULBRICH (2016) shows the screenshot of a plaster model scan - Ortho AnalyzerTM, 3Shape, DK - for semi-automatic tooth width measurement, the reproducibility of which is considered sufficiently reliable. Figure (**b**) from VON DER WENSE (2013) shows a caliper whose measuring accuracy is limited by the scaling and/or its handling. In principle, constant transmission errors can also occur with the caliper if it is used incorrectly. The own illustration (**c**) demonstrates that a measurement "parallel" to the buccal surface of the tooth does not have to correspond to a diagonal measurement of the tooth. The own illustration (**d**) shows schematically that the physical tooth width (**2**), when measured perpendicular to the tooth crown axis (**1**), does not have to be the same width as the incisal tooth width (**4**) when measured parallel to the occlusal plane (**3**).

Enamel or dentin formation disorders can also modify TWs (BAUM, 2014), but it is assumed here that BOLTON would have recognised them.

2 OBJECTIVES

The main target of this study was to extend BOLTON's 1958 analysis by using a laterally separated methodology and to compare his normal values for AR and OR with the TWSRs of white male as well as female patients with malocclusion and with different mandibular sizes.

For this purpose, one pre-target question, three intermediate-target questions, one main-target question and one post-target question had to be answered or scientifically tested with a total of eight suitable null hypotheses.

2.1 Pre-target

A pre target question was asked about the tooth width measurement methods:

Does an automatic tooth width measurement method differ from a manual tooth width measurement in terms of validity?

2.1.1 The null hypothesis on tooth width measurement methods

Null hypothesis 1: An automatic tooth width measurement made with the $SW_{2.0}$® software (Primescan™, SIRONA, D) is only more valid by chance than a manually recorded tooth width measurement using a cursor on the screen.

2.2 Intermediat-targets

Three intermediate-target questions were asked on TWs, TWSs and TWSRs:

Firstly, do the TWs in white male and/or white female patients with malocclusion differ when small, medium or large mandibles are distinguished?

Secondly, do lateral anterior [LATS], lateral total [LOTS] and lateral posterior [LPTS] TWSs differ in white male and/or female patients with malocclusion when small, medium or large mandibles are distinguished?

Thirdly, do the lateral anterior [LAR], lateral overall [LOR] and lateral posterior [LPR] TWSRs differ in white male and/or female patients with malocclusion when small, medium or large mandibles are distinguished?

2.2.1 The three null hypotheses on tooth widths

Null hypothesis 2: The TWs of individual tooth types differ only by chance in white male and/or female patients when their small, medium or large mandibles are compared.

Null hypothesis 3: TWs of homologous antagonists differ only by chance in white male and/or female patients when their small, medium or large mandibles are compared.

Null hypothesis 4: TWs of adjacent teeth differ only by chance in white male and/or female patients when their small, medium or large mandibles are compared.

2.2.2 The null hypothesis on tooth width sums

Null hypothesis 5: The lateral TWSs - [LATS], [LOTS], [LPTS] - differ only by chance in white male and/or female patients when their small, medium or large mandibles are compared.

2.2.3 The null hypothesis on tooth width sum ratios

Null hypothesis 6: The lateral TWSRs - [LAR], [LOR], [LPR] - differ only by chance in white male and/or female patients when their small, medium or large mandibles are compared.

2.3 Main-target

A main target question was asked for comparison with the norm values of BOLTON (1958):

Do the lateral anterior TWSRs [LARs] and the lateral overall TWSRs [LORs] in white patients with malocclusion and different mandibular sizes differ from BOLTON's normal values (1958) for the AR and the OR?

2.3.1 The null hypothesis on norm values by BOLTON (1958)

Null hypothesis 7: The LARs and the LORs in white male and/or female patients with malocclusion and small, medium or large mandibles differ only by chance from the norm values for normocclusion first determined by BOLTON (1958) for the AR (μ = 77.2%) and the OR (μ = 91.3%).

2.4 Post-target

A post-target question was asked to compare with the standard values for the AR and OR of MACHADO ET AL. (2019) in patients with normocclusion:

Do the lateral anterior TWSRs [LARs] and lateral total TWSRs [LORs] in white patients with malocclusion and different mandibular sizes differ from MACHADO ET AL.'s norm values (2019) for the AR (μ = 78.24%) and the OR (μ = 91.74%)?

2.4.1 The null hypothesis on norm values by MACHADO ET AL. (2019)

Null hypothesis 8: The LARs and the LORs in white male and/or female patients with malocclusion and small, medium or large mandibles differ only by chance from the globally elicited norm values for normocclusion of MACHADO ET AL. (2019) for the AR (μ = 78.24%) and the OR (μ = 91.74%).

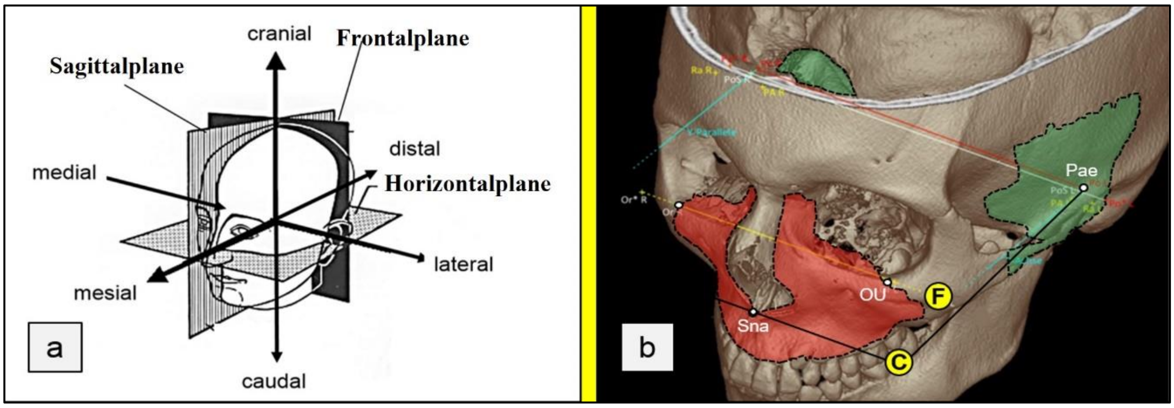
3 METHODS

3.1 Preliminary examinations for mandibular size

The main problem in answering the target questions is the fact that there is no described method in the literature how to objectify three different mandibular sizes in a clinically simple, reliable and radiograph-free way.

To describe body growth, physicians use general spatial planes as a reference, knowing full well that imprecise positioning of the body part under observation leads to a measurement inaccuracy that must be tolerated. Anthropologists and dentists tend to prefer reference planes oriented to head structures: One of the first recognised reference planes for describing cranial variability, established in the 18th century, is the Camper plane, which runs from the spina nasalis anterior to the upper edge of the porus acusticus externus (CAMPER, 1792). The Camper plane was replaced in 1877 by the Frankfurt horizontal - a projected plane through the caudal-most point on the bony orbital lower margin and the cranial-most point of the porus acusticus externus - as a reference plane (HÖLDER, 1877) (**Fig. 15**).

Figure 15| Space planes, the camper plane and the Frankfurt horizontal.

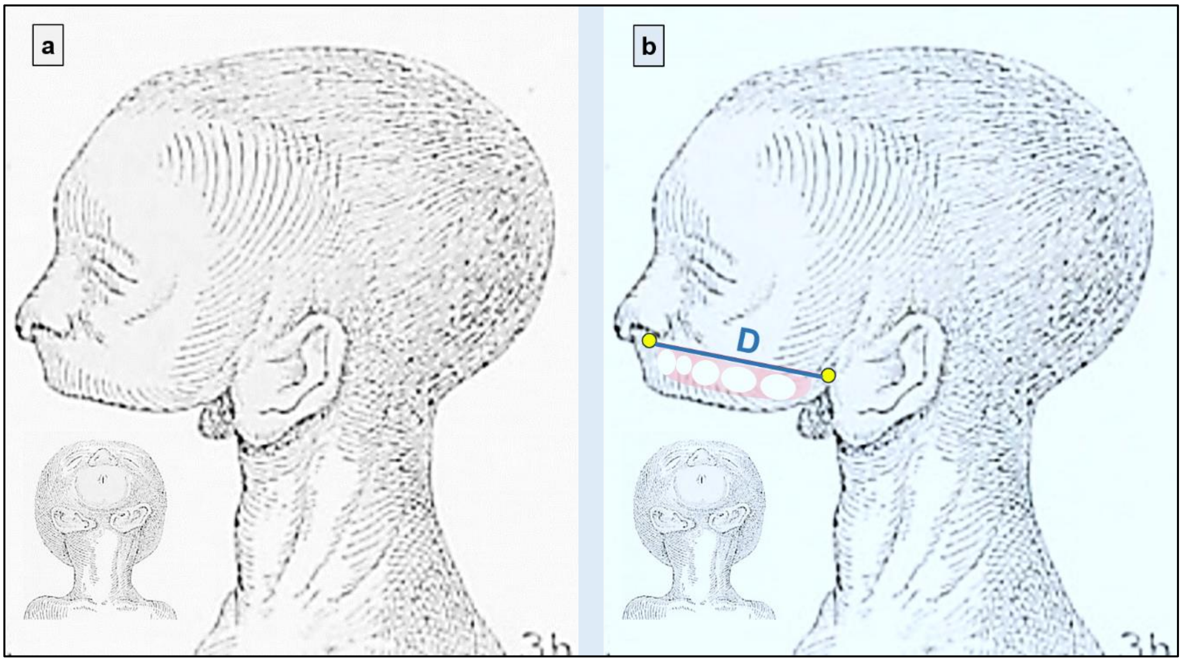


Sources for Figure 15: Figure (a) from SCHIEFERSTEIN (2003) shows the spatial planes and viewing directions commonly used in medicine. Figure (b) from KAMM (2016) - here the maxilla with the orbita lower margin [OU] was additionally marked in red and the os temporalis with the porus acusticus externus [Pae] additionally marked in green - shows the bony structures of a skull with a modified version of the Frankfurt horizontal (F). The spina nasalis anterior [Sna] and the Camper's plane (C) were subsequently added to figure (b) from KAMM (2016).

The Frankfurt horizontal, for example, was used by A. SCHWARZ (1958) to classify new face types - a nine-part classification - which he used for a preliminary assessment of the facial profile before using his cephalometric analysis as a diagnostic aid - here in particular the spina plane (nasal base, see Fig. 21); his key to cephalometric diagnosis (LOSERTH, 2008). To the best of his knowledge, he never succeeded in linking his facial classification with the spina plane and/or the TWs, TWSs and TWSRs in a diagnostically helpful way.

A drawing by G. STREETER (1922) of a new-born with a missing mandible suggests where the spina plane might be in relation to the face. The spina plane should - as is assumed here - be relatively parallel to a straight-line *D* [discriminant; discrimination plane], which runs from the most anterior point of attachment of the earlobe to the lowest point of the nostril (**Fig. 16**).

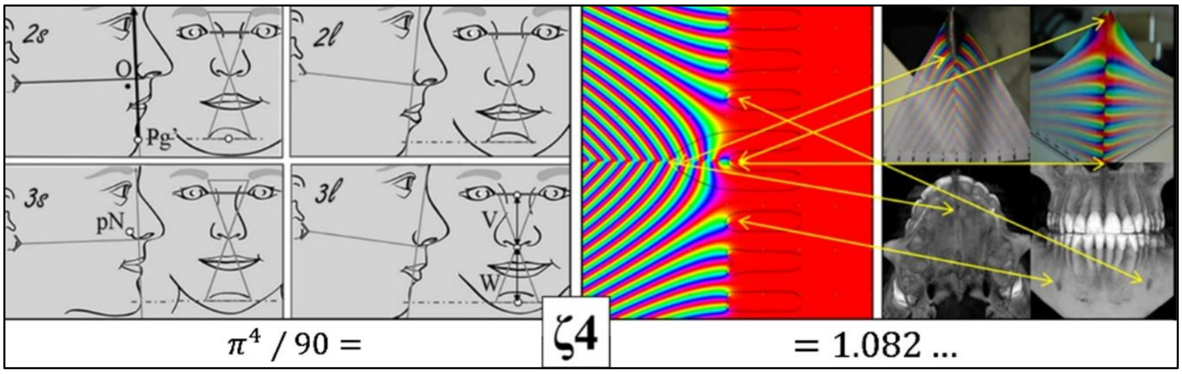
Figure 16| Discrimination plane *D.*



Sources for Figure 16: Figure (**a**) from STRETTER (1922) shows the drawing of a new-born child with a missing mandible. The own illustration (**b**) shows the drawing of STRETTER (1922), which was additionally supplemented with colour: If the most anterior point of the earlobe is connected with the lowest point of the nostril to form a straight line [discriminant D], a projective boundary plane [discriminant plane D] is created with the discriminants on both sides, which should lie relatively parallel to the floor of the nose and thus in the base of the upper jaw. In addition, the probable position of the alveolar process, which adheres to the base of the maxilla with its deciduous teeth, has been schematically drawn here.

Several master theses which did not take laterality into account at that time and a thought model that emerged from them suggest that a latent dependency that can be represented by convergence velocities may exist between the spina plane, the discrimination plane D and the TWs [dento-facial coincidence] (VOM BROCKE 2015, 2016, 2017) (**Fig. 17**).

Figure 17| The thought model for a possible dento-facial coincidence.



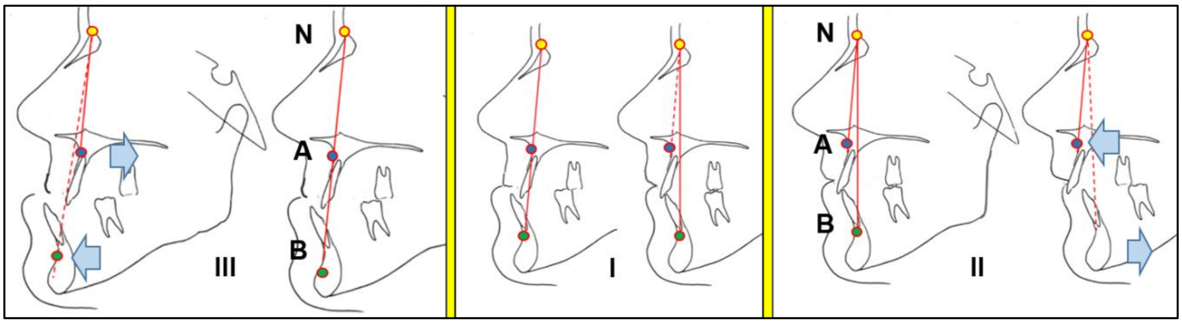
Source for Figure 17: Our own figure from VOM BROCKE (2015) - here newly compiled - is representative of an extremely complex algorithm, which as a thought model illustrates a possible coincidence of harmonic jaw growth and TWs growth. It is particularly striking that the *rectangular angle* (90°) and the *convergent limit value 1.082*... (Riemann constant) seem to play a decisive role in the interaction of dento-facial structures, the significance of which is still hardly known.

Trying to explain a theoretical model of a possibly universal dento-facial coincidence pattern with modern genetics still seems impossible today - despite the existence of supercomputers. For like a chess player who plans several moves in advance in order to bring a certain piece into a strategically significant position, the phylogenetic development of humans has been continuously adapting its structuring plan for head formation to variable adaptation factors for many millions of years of evolution and stores this plan in the DNA so that specifically important sense organs such as the eyes, the nose, the ears, the tongue, etc. are placed in relation to each other in the head in such a way that the central nervous system is supplied with the most vital information throughout life despite the most varied growth and development processes. These adaptation factors are hardly known, which is why it is important to be able to fall back on evidence-based studies that are structured in their methodology in such a way that they can later be checked with meta-analyses.

An estimation of mandibular size based on the Angle classes seems obvious at first sight, but a latent tooth width adjustment and/or a fuzzy decision boundary between the three classes could introduce a classification bias. A look at the literature suggests such a suspicion because there are authors who were able to reveal a statistically significant difference between the Angle classes and their TWSRs (TA ET AL., 2001; ARAUJO AND SOUKI, 2003) and there are other authors who failed to do so (CROSBY AND ALEXANDER 1989; UYSAL AND SARI, 2004; BASRAN ET AL., 2006).

This may be one of the reasons why the first investigations of the angle classes in combination with angular features from cephalometric x-rays [Cx] have been made for comparison with the TWSRs for about ten years. For example, WEDRYCHOWSKA-SZULC ET AL. (2010) compared the norm values of BOLTON (1958) with the TWSRs of patients with an Angle class I, II or III, whereby they subordinated the allocation to the three classes to a teleradiograph angle feature - the ANB angle. For example, patients with an ANB angle < 4° were assigned to the group with convex facial profiles (class II; small mandible) (**Fig. 18**).

Figure 18| The ANB angle method according to WEDRYCHOWSKA-SZULC ET AL. (2010).



Sources for Figure 18: The own figure schematically shows N = nasion (most ventral point of the nasofrontal suture); the A point (most dorsal and lowest point in the ventral contour of the maxilla); the B point (most dorsal and lowest point in the ventral contour of the mandible). If the ANB angle [ANB] was 0 to 4 degrees in WEDRYCHOWSKA-SZULC ET AL. (2010), then a class I was present. A class III was present with an ANB > 0 degrees and a class II was present with an ANB > 4 degrees.

In their study, the age of the patients ranged from 12 to 25 years and all had fully erupted intact permanent dentition from the first molar on one side to the first molar on the other side. Among other things, the values for AR in the groups of Angle Class II modified by cephalometric analysis differed significantly from BOLTON's standard value; on the other hand, the values for OR in this modified Angle Class II did not differ significantly from BOLTON's standard value (**Abb. 19**).

Figure 19| The results of WEDRYCHOWSKA-SZULC ET AL. (2010).

Anterior Bolton ratio	N	*P* value	Minimum	Maximum	Mean	SD
Class I male	73	***	74.4	86.2	79.1	2.20
Class I female	89	***	68.5	86.0	78.4	2.98
Class II division 1 male	60	**	72.5	84.5	78.1	2.46
Class II division 1 female	84	***	72.2	84.4	78.8	2.63
Class II division 2 male	67	***	71.5	83.8	78.4	2.71
Class II division 2 female	88	***	72.5	87.3	78.4	2.80
Class III male	62	***	73.2	89.2	80.1	3.00
Class III female	77	***	70.9	88.5	78.9	2.89
Total male	262	***	71.5	89.2	78.9	2.70
Total Female	338	***	68.5	88.5	78.6	2.83
Total	600	***	68.5	89.2	78.8	2.77

Overall Bolton ratio	N	*P* value	Minimum	Maximum	Mean	SD
Class I male	73	***	87.9	97.8	92.3	1.86
Class I female	89	NS	86.5	96.0	91.9	2.09
Class II division 1 male	60	NS	86.0	95.9	91.2	2.22
Class II division 1 female	84	NS	83.9	95.9	91.1	2.16
Class II division 2 male	67	NS	84.7	96.1	91.7	2.21
Class II division 2 female	88	NS	86.7	99.1	91.5	2.23
Class III male	62	***	86.6	98.0	93.0	2.29
Class III female	77	**	86.4	97.7	92.0	2.46
Total male	262	***	84.7	98.0	92.1	2.22
Total Female	338	**	83.9	99.1	91.6	2.25
Total	600	***	83.9	99.1	91.8	2.24

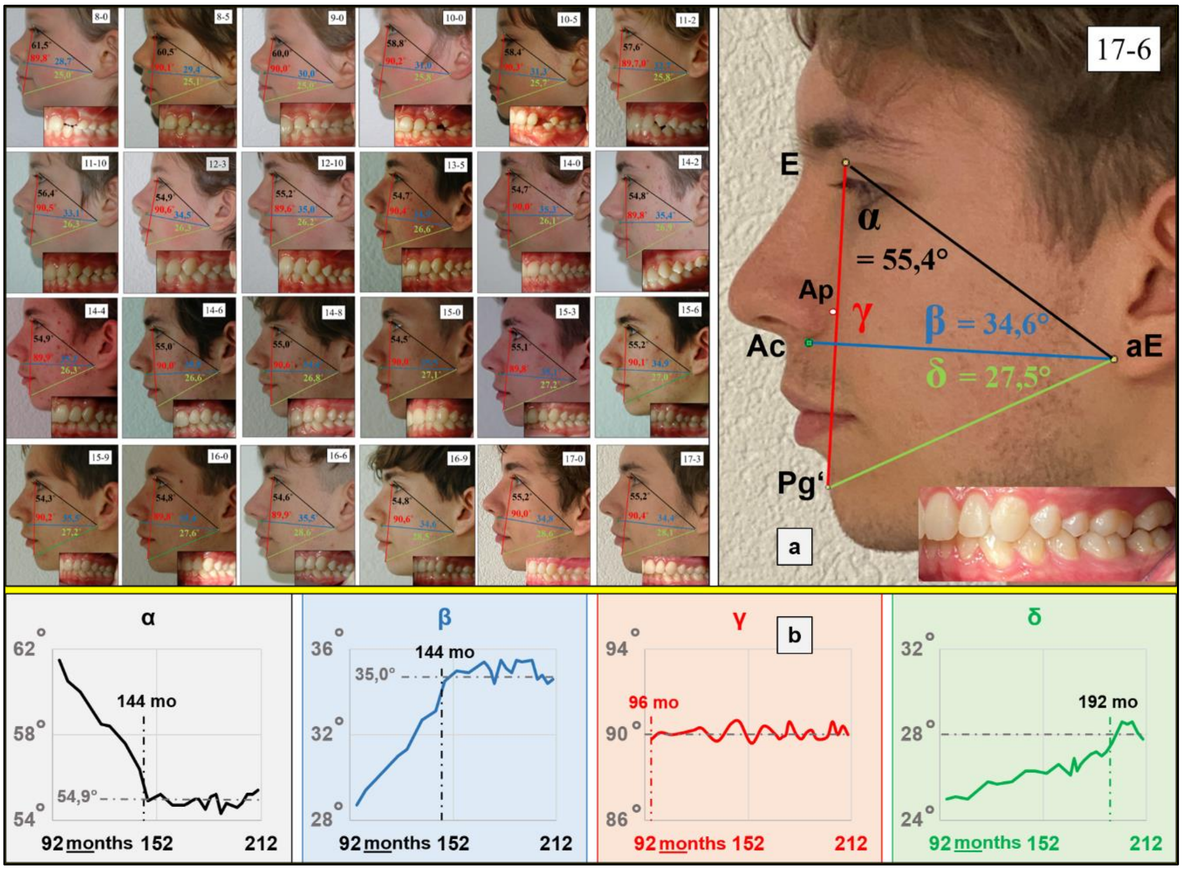
NS, not significant. ***P*<0.01, ****P*<0.001.

Source for Figure 19: The figure from WEDRYCHOWSKA-SZULC ET AL. (2010) shows how the AR and OR differ significantly from BOLTON's norm values in the patient pool. The distal bite was still divided into a class II/1 and II/2 based on the anterior tooth positions.

However, the method of WEDRYCHOWSKA-SZULC ET AL. (2010) cannot be said to have good reliability, because although its OR (μ = 91.2%) matched BOLTON's norm value ORμ = 91.3% for Class II, the AR (μ = 78.1%) of the same Class II subgroup was significantly greater than BOLTON's norm value for ARμ = 77.2%. From a purely plausible point of view, should not the same patient subgroup behave in the same way as the OR_{μ} and the AR_{μ} of BOLTON (1958)?

To clarify how the mandibular sizes could be determined based on the discrimination plane ***D***, facial angle changes in the son of the author were evaluated in the period from 8 years to 17 years 6 months (**Abb. 20**).

<u>Figure 20|</u> A Long-term study of facial angle changes in the author's son.

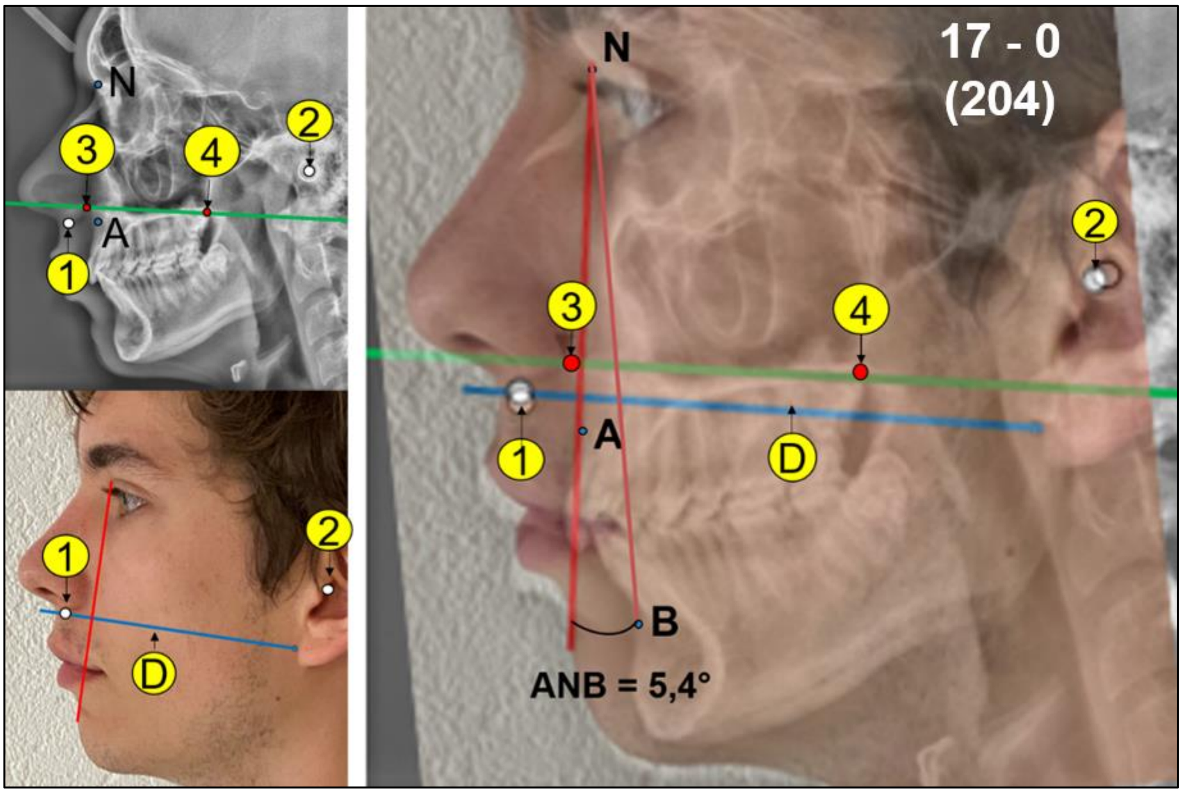


Sources for Figure 20: The own figure (a) shows 25 photographed images of the left facial profile of the author's son between the ages of 8 years to 17 years and 6 months with four facial angles - measured with Romexis® version 4.4.3 (PLANMECA, Fin) - drawn in and measured. These were the eye angle α [α = Ac-aE-E], ear angle β [β = aE-E-Pg'], maxillary angle γ [γ = 180˚-α-β] and mandibular angle δ [δ = Pg'-aE-Ac]. Here Ac [Alara caudale] is the lowest point tangential to the nasal wing. E [Eye point] is the most anterior point of the upper eyelid crease. aE [anterior Earlobe point] is the most anterior point at the base of the earlobe in relation to Ac. Pg' [soft tissue pogonion] is the most anterior soft tissue point of the chin. The own figure (b) shows how, in the author's son, for example, β increases in size by about six degrees between the ages of eight and twelve and thereafter remains relatively constant at 35˚± 0.5 ˚ in size. The own figure (b) shows how, in the author's son, for example, β increases in size by about six degrees between the ages of eight and twelve and thereafter remains relatively constant at 35˚± 0.5˚ in size. During the total observation period of 9½ years, γ remained practically constant 90.0˚ ± 0.5˚ and the straight line Pg'-E was always tangent to the nostril at the most posterior point Ap [Alara posterior]. δ permanently increases until about the age of 16 years (192 months). The straight line aE-Ac = D [D = discriminant; $D_{r/l}$ = plane of discrimination] forms a practically spatially constant reference plane here.

Of course, the long-term case study presented does not allow any generalisation but leads to the following four conclusions only for the author's son: His vertical maxillary growth is slowed down before puberty. His vertical mandibular growth is slowed down after puberty. The growth of his maxillary and mandibular dental arches is parallel to each other from permanent dentition at the latest. With an orthogonal O to the discrimination plane D, the sagittal mandibular size in relation to the anterior nasal space can be described in his case: "His lower jaw is too small to reach his anterior nasal space".

An overlay of the facial profile with a cephalometric radiograph taken at the same time proves, among other things, an almost parallelism between the spina plane [NL = nasal line; Spa-Spp] and the plane of discrimination D (**Fig. 21**).

Figure 21| Superimposition of a side profile photo with a cephalometric image.



Quelle zur Abbildung 21: Die eigene Abbildung zeigt die Überlagerung des Seitenprofilfotos des damals 17-jährigen Sohnes des Autors mit seinem Fernröntgenbild an den Punkten Ac [Alara caudale] (**1**) und Pae [Porus acusticus externus] (**2**). Die Überlagerung enthüllt einen nahezu parallelen Verlauf der Spina-Ebene [spina nasalis anterior (**3**) zur spina nasalis posterior (**4**)] zur Diskriminationsebene *D* und gleichzeitig eine “beinahe“ perfekte Überlagerung der Orthogonalen mit der Verbindungslinie A zu N. Der ANB-Winkel betrug 5,4° (Romexis® Version 4.4.3, PLANMECA, Fin).

In the author's then 17-year-old son, the ANB angle was 5.4°, for which reason WEDRYCHOWSKA-SZULC ET AL. (2010) would have assigned him a convex face.

3.2 Study design

To improve the objectivity of the results, a randomised and blinded study design was chosen for the planned study. Four dental practices [patient collectors] - a dental practice specialising in oral surgery in Vaduz (Dr M. Meier; Liechtenstein), a practice for general dentistry in Wegberg (Dr O. Stehle; Germany), a practice for orthodontics in Waldbröl (Dr J. Arnold; Germany) and a practice for orthodontics in Zwickau (Dr U. Loeffler; Germany) - made themselves available for this purpose. The patient collectors collected as many white patients with regular permanent dentition as possible, who had an orthodontic concern but had not had orthodontics before and who were willing to provide their data for this project work, in a period limited to six months (April 2019 to September 2019). The following classic clinical records were obtained from all patients in accordance with practice usage. A lateral extraoral photograph of the left and an extraoral photograph of the right side of the face (in maximum intercuspidation [IK]) were taken, as well as an alginate impression of the maxillary dentition and one of the mandibular dentition. These impressions were cast with plaster to form study models. The two digital lateral profile photographs of the patients were taken at a distance of two metres, in maximum intercuspidation, without duplicate structures, with visible external auditory canal, in order to be able to determine the relative mandibular size (method see chapter 3.3.4) without distortion. Exclusion criteria for admission to data collection would have been persistent habits after 6 years of age, birth defects or known genetic defects, oral surgery or orthodontic history, non-intact or filled permanent teeth, deciduous dentition, mixed dentition and status after facial trauma. The history and findings were taken by the respective practitioners in the respective practices.

Patient information and signed informed consent were the preconditions for participation in the study. It was explained to all participating persons that the data elicited from the diagnostic records would be used in a completely anonymised form. Even after the discussion of the prepared documents, the patients did not want to change their consent, which they could have done at any time, however, which would then have resulted in exclusion from the study without disadvantage. The not fully anonymised profile pictures on figures 20, 21, 34 to 38, 40, 43, 45 and 46 were of patients who were not part of the study pool. These patients had handwritten on a consent form that their images and the information derived from them could be used for this work.

Plaster models and two lateral profile photos of each of 91 people with pre-orthodontic status were obtained. Of these 91 persons, 10 patients also had a status after orthodontics at the end of the 6 months. These 10 cases were used as a quasi-random sample for the measurement error analysis of the measurement method errors in the tooth width measurements (method see Chapter 3.3.3).

After the six months of recording patient records, the author was invited to the practice of the proband collectors to scan the made plaster models using a 3D scanner (Primescan^{TM}, SIRONA, D) and to photograph the two lateral profile photos using a smartphone (iPhone 9^{TM}, APPLE, USA). For blinding purposes, the plaster models were labelled only with the patient card number [ID number] and date of birth. Separately from these, he received all the lateral facial profile images taken, which were only labelled with the patient's surname and first name for blinding purposes. Thus, only the patient collectors knew the coding of the ID number to the patient names until the time of the statistical data analysis, which guaranteed blinding.

After data collection by the author, the patient collectors only gave the statistician the "assignment key" to the patient ID numbers and the corresponding patient names. The statistician received two completed Excel files from the author "at the same time". One Excel file contained the gender assigned to the patient names and the relative mandibular sizes, which had been determined from the lateral profile photos (for method see chapter 3.3.4). The other Excel file contained the patient age assigned to the ID numbers and the measurement data obtained for the TWs (for methods see Chapter 3.3.1 and 3.3.2). The statistician was only informed of the target questions or the eight hypotheses of this dissertation after he had merged these two tables.

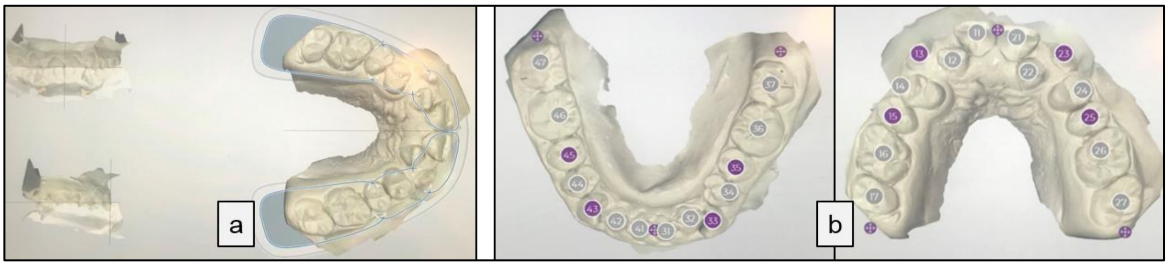
3.3 Data collection and allocations

The data collection of the TWs for the different comparisons and the allocations of the comparisons as well as the mandibular sizes were done by the author.

3.3.1 The automatic tooth width measurement by the software $SW_{2.0}$®

The measurements of the TWs made automatically by the software $SW_{2.0}$® were obtained after the scans had been centred in virtual space according to their occlusal plane and all teeth had been marked (**Fig. 22**).

<u>Figure 22I</u> The automatic TWs measurement made by the SW2.0® software.

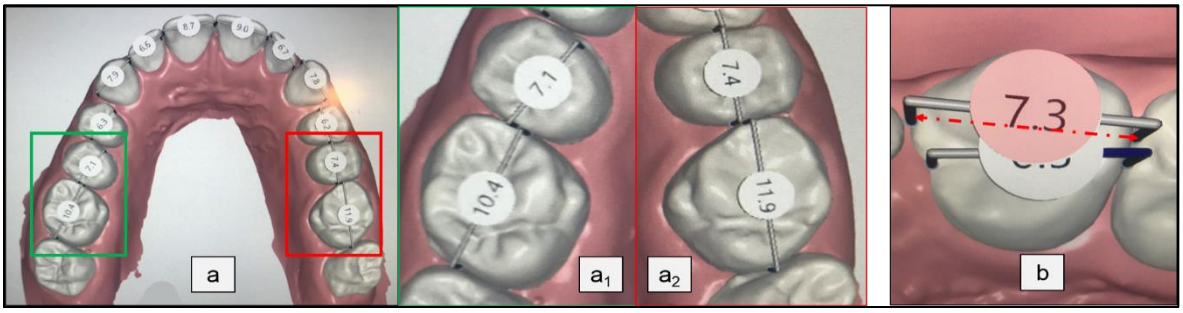


Sources for Figure 22: The own screenshot (**a**) shows the setting of a dentition scan (Primescan™, SIRONA, D) using the occlusal plane - occlusal plane = connection of the disto-buccal cusp tip of m_2 with the incisal edge of i_1 - and the raphe mediana palatina in virtual space. The own screenshot (**b**) shows the marked lower and upper teeth.

3.3.2 The manual tooth width measurement on the screen

In addition to the automatic tooth width measurement, a tooth width measurement was also made manually [manually] using a cursor on the screen (**Fig. 23**).

<u>Figure 23I</u> A comparison of the automatic and manual TWs measurements.



Sources for Figure 23: The own screenshot (**a; a_1/a_2**) of the scan shows the automatic measurement of the maxillary teeth, whereby here - presumably due to the rotation of tooth 26 - tooth 26 is measured 15% wider than tooth 16. The own screenshot (**b**) shows, for example, on tooth 24, how the maximum mesio-distal TW (red; here 7.3 mm) was always measured during the manual measurement, which was usually located in the buccal and not in the oral half of the tooth.

3.3.3 The measurement error analysis

To clarify which of the two tooth-width measuring methods should be used to answer the three intermediate-target questions, the main-target question and the post-target question, it was first necessary to objectify the validity of the two tooth-width measuring methods by means of a known measurement error analysis and also to compare them with each other.

To objectify the validities of the two tooth width measuring methods - automatic and manual - the TWs measuring method errors were calculated in the form of MF values (MF = measuring method error) of the 24 individual tooth types (16 to 26 and 36 to 46).

The MF value of a certain tooth type was calculated by means of registered measurement value fluctuations *d* - difference from a first measurement and a second measurement - and a formula – $\boldsymbol{MF} = \sqrt{(\sum d^2)/2n}$ – according to DAHLBERG (1940) on measurement method errors. The MF value is the square root of the sum of squared measured value fluctuations in relation to the number of measurements.

The MF value calculation according to DAHLBERG (1940) is one way of comparing the validities of other tooth width measurement methods described in the literature. In principle, according to DAHLBERG (1940), a MF value smaller than 1 was considered reliable.

As a quasi-random sample for the comparison of the automatic and manual tooth width measurement, the 3D model scans of the ten patients (number of teeth of one tooth type compared = 10) were used, who had plaster models with status before orthodontics as well as plaster models with status after orthodontics.

d = tooth width measurement difference = measured value fluctuation

(d = measurement before orthodontics minus measurement after orthodontics)

n = number of compared teeth of one tooth type

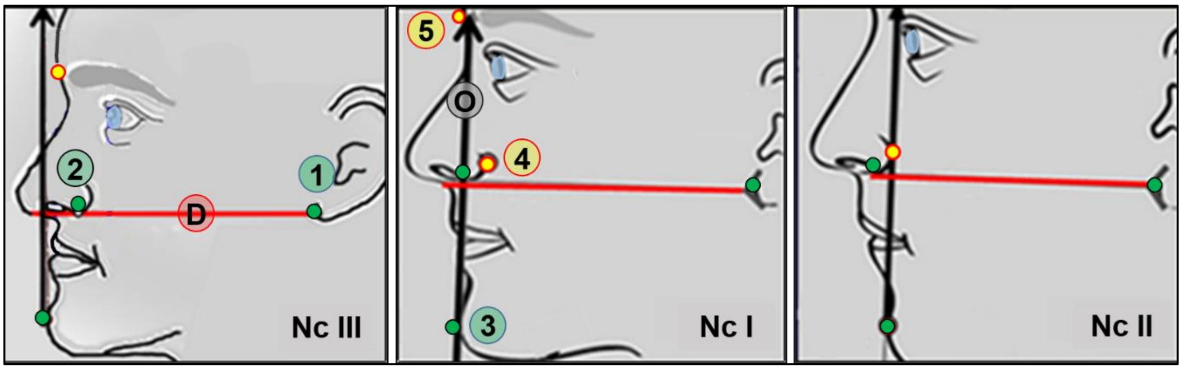
2n = number of tooth width measurements taken

Using the appropriate analytical statistics, the *MF values* of the automatic measurements were compared with the *MF values* of the manual measurements to compare the validities of the two tooth width measurement methods.

3.3.4 The classification of mandibular sizes

To distinguish three possible mandibular sizes, the author photographed the provided patient profile photos with his iPhone (G9®, Apple, USA) and transferred the images to his laptop. Using a presentation programme (PowerPoint®, Microsoft, USA), he drew the discriminant D on the profile pictures and distinguished three different mandibular sizes in relation to the anterior nasal space [Norma class (abbreviated: NK) I, II or III; "Norma" (Latin) = Right angle] with a vector O (orthogonal to D) (**Fig. 24**).

Figure 24| The three mandibular sizes [the Norma classes I, II and III].



*Source for Figure 24: The own figure shows how the photographed facial profile was used for the assignment into one of three mandibular sizes [Norma classes: Nc I; Nc II or Nc III]. On both sides a discriminating baseline was drawn from the most anterior point of the base of the earlobe [aE] (**1**) tangential to the most caudal point of the nostril [Ac = Alara caudale] (**2**).* The abstract tangent of aE to Ac - called discriminant D - served as a projected separation plane between the morphological upper and lower face. The soft tissue pogonion point [Pg'] (3) - most anterior point of the mandible - was used as the starting point for an orthogonal [O] (orthogonal angle γ' = 90˚) to D. O was used as the gnathological parting plane of the mandibular size: If O passed over or posterior to the rearmost point of the nasal wing [Ap = alara posterior] (4), then the individual was assigned a small mandibular side [NK II = convex face type; facial retrognath]. If O passed between Ap and the most anterior point between the eyebrows [Gl = glabella] (5) or above it, the person was assigned a medium sized lower jaw side [NK I = straight face type; facial eugnath]. If O passed in front of Gl, it was assigned a large mandibular side [NK III = concave face type; facial prognath]. The tolerance of classification error is estimated at ± 1mm.

From here on, the area above the discriminant D is called the morphological upper face and the area below it the morphological lower face.

3.3.5 The comparisons of the tooth widths

In total, three different tooth width comparisons were carried out in the six subgroups - two sexes with three Norma classes each - and any probabilisation between the subgroups was also checked:

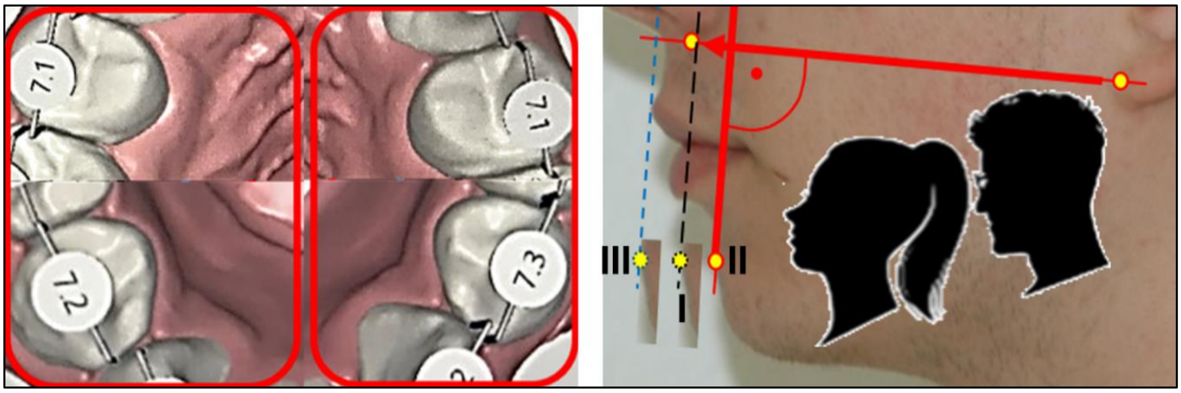
3.3.5.1 Firstly: TW comparisons between the same tooth types

The first twelve permanent teeth - maxilla: I_1, I_2, C, P_1, P_2, M_1; mandible: i_1, i_2, c, p_1, p_2, m_1 - were tested for TWs differences in the subgroups.

3.3.5.2 Secondly: TW comparisons between homologous antagonists

TWs of homologous antagonists were tested with the Wilcoxon test (**Fig. 25**).

Figure 25| The TWs of homologous antagonists in the Norma classes and in the sexes.

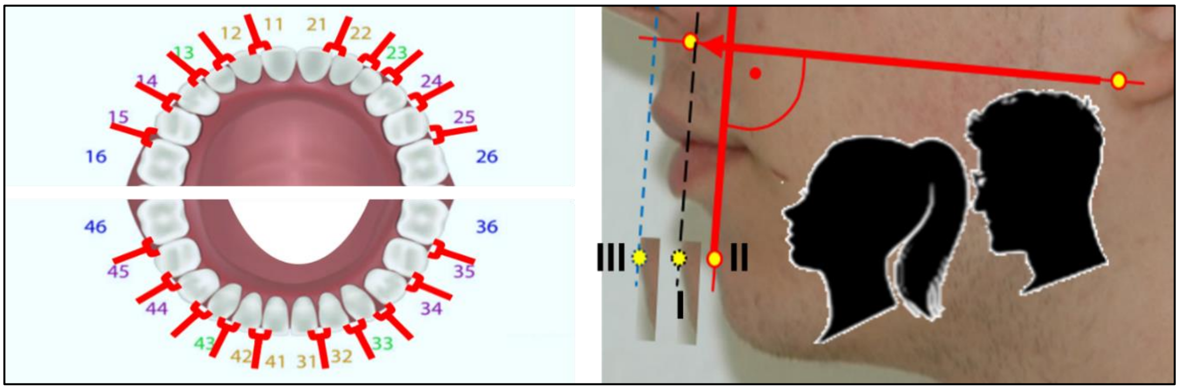


Source for Figure 25: The own figure shows the first premolars as homologous antagonists in the 6 subgroups (three mandibular sizes per sex).

3.3.5.3 Thirdly: Tooth width comparisons between neighbouring teeth

TWs of neighbouring teeth were tested with the Wilcoxon test (**Fig. 26**).

Figure 26| The TWs of neighbouring teeth in the Norma classes and in the sexes.

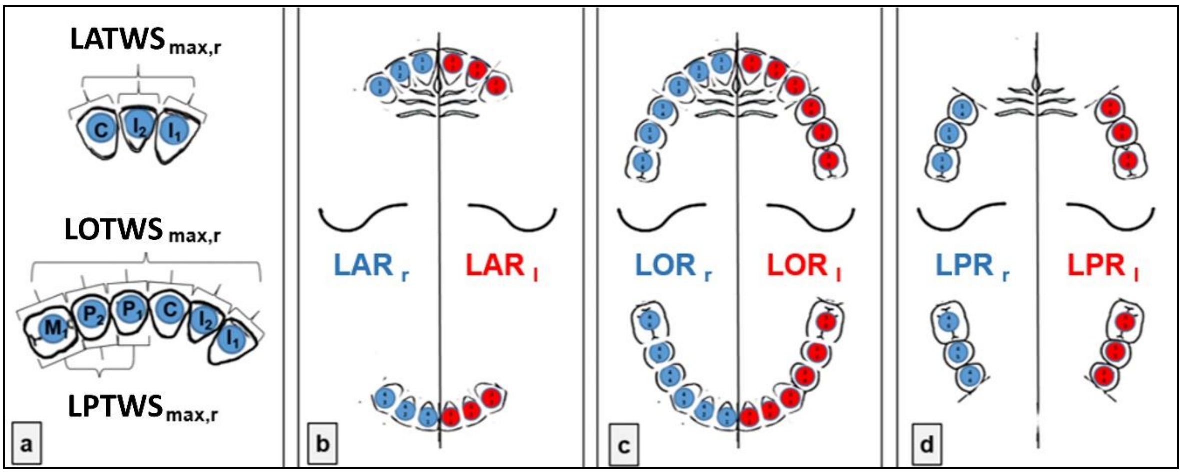


Source for Figure 26: The own figure shows schematically the neighbouring teeth in the 6 subgroups (three mandibular sizes per sex).

3.3.6 The calculation of the tooth width sums and TWSRs

The TWs were added up to three different lateral tooth width sums [LTWSs]. Thus, a lateral anterior width sum [LATS], a lateral overall width sum [LOTS] and a lateral posterior width sum [LPTS] could be distinguished (**Fig. 27a**). Three different lateral intermaxillary tooth width sum ratios [LTWSRs] were calculated from the LTWSs: Lateral anterior ratio [LAR], lateral overall ratio [LOR] and lateral posterior ratio [LPR] (**Fig. 27b-c**).

Figure 27l The lateral TWSs and the lateral TWSRs.



Source for Figure 27: The own figure (**a**) shows the methods for calculating the lateral TWSs: The upper right anterior width sum [$LATWS_{max,r}$], the upper right total tooth width sum [$LOTWS_{max,r}$] and the upper right posterior width sum [$LPTWS_{max,r}$]. Figure (**b**) shows the method for calculating lateral tooth width sum ratios of the lateral anterior ratios [LARs] type. The LAR is calculated laterally separated. For example, on the right: LAR_r = 100 x $(i1+i2+c)_r$ / $(I1+I2+C)_r$ = 100 x [$LATWS_{man,r}$] / [$LATWS_{max,r}$]. The calculation principle is the same as in the original Bolton analysis, except that there are two values per patient. Figure (**c**) shows the method for calculating the lateral overall ratios [LORs]. Figure (**d**) shows the method for calculating the tooth width sum ratios of the lateral posterior ratio type [LPRs].

The $LATWS_{max}$, $LATWS_{man}$, $LPTWS_{max}$, $LPTWS_{man}$, $LOTWS_{max}$, $LOTWS_{man}$, LAR, LOR and LPR were tested for differences in the sexes and in the three different mandibular sizes and were also compared with the norm values for the OR_{μ} and AR_{μ} of BOLTON (1958) and with the norm values for globalised norm occlusions of MACHADO ET AL. (2019).

The LAR, LPR and LOR are collectively called lateral TWSRs [LTWSRs].

3.4 Data evaluation

The evaluation and presentation of the 182 lateral data sets from the 91 patients was done by own tables and bar charts according to descriptive and analytical data according to the programme SPSS Statistics 23® (IBM, USA).

The analytical statistics were carried out by an experienced bio-statistician - Univ. Prof. Mag. Dr. PhDr. Willhelm Frank MLS - who was very familiar with the SPSS Statistics 23® programme (IBM, USA) for testing cephalometric characteristics such as the TWs. The definitive goal of this dissertation was only made known to the statistician after the analyses, which is why the data evaluation can also be regarded as blinded.

The tests for normal distribution were carried out using the Kolmogorov-Smirnov test [KS test]. The KS test is an analytical test that compares the distribution of the collected data with a normal distribution curve. If the two distributions differ with a probability of $p \leq 0.05$, then there is no normal distribution. In the case of a normal distribution, parametric follow-up tests were used, and in the case of a non-normal distribution, non-parametric follow-up tests were used.

The means of two independent sample groups, which were normally distributed, were tested for differences in their populations using the two-tailed Student's t-test. If the probability of agreement was less than $p \leq 0.05$, it was assumed that the two samples did not differ by chance. If the samples were not normally distributed, the Mann-Whitney non-parametric follow-up test [U-test] was used.

Testing for a possible imbalance in the distribution of parameters - such as age - in the three mandibular sizes small, medium and large was done with the Kruskal Wallis test [H-test]. If the p-value of the H-test was ≤ 0.05, then a certain age would have been over-represented in one of the three different mandibular sizes.

Testing for possible differences of dependent samples - comparisons within the same patient - was done with the non-parametric Wilcoxon test [W-test]. This test checks the equality of the central tendency - median values. If the p-value of the W-test was ≤ 0.05, then the measured values of the samples were not only different by chance, or they differed significantly. For reasons of uniform presentation, the value for the central tendency was not given in the descriptive tables, but rather the mean value [μ] (dental practice), although this is methodologically not entirely pure.

The tests for possible correlations between the genders and the mandibular sizes were carried out using Pearson's chi-square test [C-test]. With a p-value of ≤ 0.05, this stochastic independence test proves that the two compared characteristics are dependent on each other.

In general, an alpha probability value of p ≤ 0.05 was used as a cut-off decision to be able to reveal significant - non-random - differences in the TWs, LTWSs and LTWSRs when comparing mandibular sizes and genders:

An alpha value of p > 0.1 was designated as non-significant.
An alpha value of p ≤ 0.1 was designated as tending to be significant.
An alpha value of p ≤ 0.05 was designated as significant.
An alpha value of p ≤ 0.01 was designated as highly significant.
An alpha value of p ≤ 0.001 was designated as highly significant.

The test for differences in the p-value probabilities [probabilisation test] of subgroups is carried out using a simple or paired t-test, because it is assumed that p-values are in principle normally distributed.

The tests for possible differences in the data distribution in relation to other norm values were also carried out with the t-test for reasons of test homogeneity.

4 RESULTS

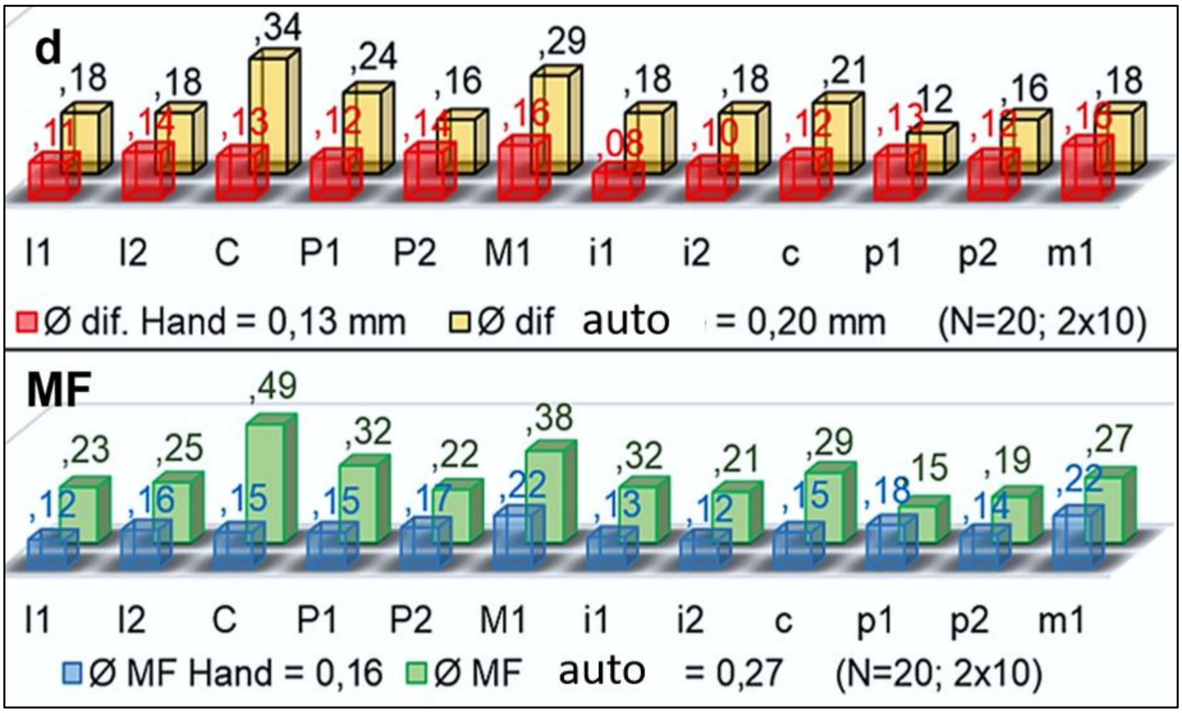
All results for measurement error analysis, TWs, TWSs, TWSRs, comparisons with the standard values of BOLTON (1958) and the standard values of MACHADO ET AL. (2019) were presented in figures or tables.

4.1 On the measurement error analysis

To compare the validity of the tooth width measurement methods, the MF values were calculated from the measurement fluctuation widths *d* (*d* = measurement inaccuracy) of all tooth types of the ten quasi-randomly recorded - also finished treated – patients

The measurement error d in the manual measurement was on a mean d_{μ} = 130 µm and in the automatic measurement the mean measurement error was d_{μ} = 200 µm. The calculated MF values were all smaller than 0.5, whereby as a rule (except for the MF values for p_1) the MF values calculated from the manual measurements were smaller than the MF values calculated from the automatic measurements (**Fig. 28**).

Figure 28| The variability of the tooth width measurements *d* and their MF values.



Source for Figure 28: The own figure shows the result for the validity of the measurement methods. For the manual measurement, the mean measurement error was d_{μ} =130 µm and for the automatic measurement, d_{μ} = 200 µm. The highest MF value was 0.47 - after automatic measurement.

An analytical simultaneous comparison of the MF values using Student's t-test - the MF values of both methods were normally distributed - revealed that the MF values from the manual measurements were highly significantly (p = 0.002) smaller than those calculated from the automatic measurements (**Table 1**).

Table 1I *t*-test on the MF values of the two tooth width measurement methods.

The t-test for the difference in MF values between manual and automatic measurements										
Manually Automatically		μ = 0,1592	N = 12	St.D = ,0337	Standard error of the mean = 0,00973					
		μ = 0,2692	N = 12	St.D =,0924	Standard error of the mean = 0,02667					
t-Test		Paired differences: Mean value	Std. Deviation	Standard error of the mean	95% confidence interval of the difference: Lower	Upper	T	df	Significance
Pair	Manually Automatically	-,1100	,09105	,02629	-,16785	-,05215	-4,185	11	**p = 0,002 ****

Source for Table 1: The own table shows the p-values with significance * = p ≤ 0.05 for differences in the MF values.

The analytical result on the MF values reveals that the validity of the manual measurement method is randomly better than that of the automatic measurement method with the software SW2.0®.

Based on this result, all further analyses to answer the three intermediate target questions, the main target question and the post-target question were only carried out with the TWs measured by hand.

4.2 On data distribution

1. The age distribution ranged from 144 to 529 months with μ = 197 ± 47 months in males (N = 39) and μ = 210 ± 75 months in females (N = 52) and the age was not normally distributed (p ≤ 0.001; Kolmogorov-Smirnov test).

2. The Kruskal-Wallis test proved that there was no significant (p = 0.655) age difference in the Norma classes.

3. The chi-square test proved that there was no significant (p = 0.642) correlation between genders and Norma classes.

4.3 On the tooth widths

4.3.1 Comparisons of individual tooth types

Table 2 provides descriptive evidence of the data distribution of TWs of individual tooth types in the entire pool, the genders and in the six subgroups.

Table 2l Description of TWs of tooth types in the partial- and subgroups.

TWs μ and St. Dev. in mm	I_1	I_2	C	P_1	P_2	M_1	i_1	i_2	c	p_1	p_2	m_1
All (N = 182)	**8,5**	**6,7**	**7,7**	**7.0**	**6,7**	**10,2**	**5,3**	**5,9**	**6,7**	**7,0**	**7,1**	**10,9**
First standard deviation	0.6	0,5	0,4	0 ,4	0,4	0,6	0,3	0,4	0,4	0,5	0,4	0,6
Female (N = 104)	**8,5**	**6,6**	**7,6**	**6,9**	**6,6**	**10,2**	**5,2**	**5,8**	**6,6**	**6,9**	**7,1**	**10,8**
First standard deviation	0.6	0,5	0,5	0 ,4	0,4	0,6	0,3	0,4	0,4	0,5	0,4	0,6
Maximum	10,1	7,6	8,7	8,0	8,7	11,4	6,0	6,9	7,7	8,2	8,0	11,9
Minimum	7,1	5,6	6,6	5,9	5,8	8,8	4,1	4,7	5,6	5,8	6,0	9,3
Male (N = 78)	**8,6**	**6,8**	**7,8**	**7,0**	**6,8**	**10,4**	**5,3**	**5,9**	**6,8**	**7,1**	**7,2**	**11,0**
First standard deviation	0,6	0,6	0,4	0,4	0,4	0,5	0,3	0,3	0,4	0,5	0,4	0,6
Maximum	10,1	7,9	8,6	7,8	7,7	11,5	5,9	6,8	7,8	8,7	8,2	12,2
Minimum	7,3	5,8	7,2	6,3	5,8	9,4	4,7	5,1	5,8	6,3	6,4	9,9
Female Norma class I (N = 43)	**8,5**	**6,6**	**7,5**	**6,8**	**6,7**	**10,1**	**5,3**	**5,9**	**6,6**	**7,0**	**7,0**	**11,0**
First standard deviation	0,6	0,4	0,3	0,4	0,4	0,5	0,3	0,3	0,3	0,5	0,4	0,6
Female Norma class (N = 47)	**8,4**	**6,7**	**7,6**	**6,9**	**6,5**	**10,2**	**5,2**	**5,6**	**6,5**	**6,8**	**7,0**	**10,6**
First standard deviation	0,5	0,5	0,5	0,4	0,4	0,6	0,3	0,4	0,4	0,4	0,4	0,6
Weiblich Norma class (N = 14)	**8,5**	**6,6**	**7,8**	**7,2**	**6,8**	**10,1**	**5,3**	**6,2**	**6,8**	**7,2**	**7,2**	**11,1**
First standard deviation	0,7	0,5	0,4	0,4	0,5	0,6	0,3	0,4	0,4	0,4	0,4	0,6
Male Norma class (N = 29)	**8,8**	**6,9**	**8,0**	**7,1**	**6,8**	**10,5**	**5,4**	**6,1**	**7,0**	**7,2**	**7,3**	**11,2**
First standard deviation	0,6	0,6	0,4	0,3	0,3	0,4	0,2	0,4	0,3	0,4	0,3	0,5
Male Norma class (N = 33)	**8,6**	**6,7**	**7,7**	**7,0**	**6,7**	**10,4**	**5,3**	**5,8**	**6,7**	**7,1**	**7,1**	**10,9**
First standard deviation	0,6	0,5	0,4	0,4	0,5	0,6	0,3	0,3	0,4	0,5	0,4	0,6
Male Norma class (N = 16)	**8,5**	**6,8**	**7,7**	**7,0**	**6,9**	**10,1**	**5,3**	**5,9**	**6,9**	**7,1**	**7,2**	**11,0**
First standard deviation	0,4	0,4	0,3	0,5	0,5	0,5	0,2	0,2	0,3	0,3	0,4	0,5

Source for Table 2: The own table shows the mean values and the first standard deviations of the TWs from the different tooth types in the total pool, in the partial groups and in the subgroups.

Testing the TWs of individual tooth types for normal distribution using the Kolmogorov Smirnov test (KS test) revealed that the majority of teeth did not have a normally distributed TWs data distribution. The canines in the upper jaw were the only teeth with a normally distributed data set in both sexes (**Tab. 3**).

Table 3| KS-tests on the TWs.

TW Normal distribution	I_1	I_2	C	P_1	P_2	M_1	i_1	i_2	c	p_1	p_2	m_1
Female: *p* =	**,005***	**,001***	,200	**,006***	,151	**,008***	**,049***	**,035***	**,042***	**,003***	**,035***	**,016***
Male: *p* =	**,001***	**,033***	,200	,200	**,031***	,056	,086	**,029***	,200	**,034***	**,015***	**,022***

Source for Table 3: The own table shows the p-values with significance * = p ≤ 0.05 after checking the data on the manually measured TWs for normal distribution.

Analytical testing with the U-test revealed, among other things, that the upper lateral incisors [I_2] were the only tooth types that did not differ significantly in any single partial- or subgroup comparison and that the upper second premolars [P_2] differed most markedly between the subgroups. The probabilistic difference - tested using the paired t-test - between I_2 and P_2 was significant (p = 0.011) and that between I_2 and M_1 was even highly significant (p = 0.008) (**Table 4**).

Table 4| U-tests on the TWs of the individual tooth types in the partial and subgroups.

Tooth types µ & p values	I_1	I_2	C	i_1	i_2	c	P_1	P_2	M_1	p_1	p_2	m_1
Female µ	8,5	6,6	7,6	6,9	6,6	10,2	5,2	5,8	6,6	6,9	7,1	10,8
All p =	**,028***	,172	**,003***	**,030***	**,025***	**,001***	,066	,062	,053	**,013***	,052	,151
Male µ	8,6	6,8	7,8	7,0	6,8	10,4	5,3	5,9	6,8	7,1	7,2	11,0
Nc III µ	8,5	6,6	7,8	7,2	6,8	10,1	5,33	6,2	6,8	7,2	7,2	11,1
Female p =	,918	,801	**,008***	**,005***	,362	,919	,472	**,019***	,085	,234	,328	,457
Nc I µ	8,5	6,6	7,5	6,8	6,7	10,1	5,26	5,9	6,6	7,0	7,0	10,9
Nc II µ	8,4	6,7	7,6	6,9	6,5	10,2	5,2	5,6	6,5	6,8	7,0	10,6
Female p =	,653	,881	,437	,551	,125	,802	,284	**,010***	,129	,096	,629	**,008***
Nc I µ	8,5	6,6	7,5	6,8	6,7	10,1	5,3	5,9	6,6	7,0	7,0	10,9
Nc II µ	8,4	6,7	7,6	6,9	6,5	10,2	5,2	5,6	6,5	6,8	7,0	10,6
Female p =	,959	,952	,132	**,017***	,102	,911	,137	**,001***	**,009***	**,001***	,782	**,012***
Nc III µ	8,5	6,6	7,8	7,2	6,8	10,1	5,3	6,2	6,8	7,2	7,2	11,1
Nc III µ	8,5	6,8	7,7	7,0	6,9	10,1	5,3	5,9	6,9	7,1	7,2	11
Male p =	,088	,336	**,012***	,490	,962	**,009***	**,047***	**,048***	,062	,452	,445	**,036***
Nc I µ	8,8	6,9	8,00	7,1	6,8	10,5	5,4	6,1	7,0	7,2	7,3	11,2
Nc II µ	8,6	6,7	**7,7**	7,0	6,7	10,4	5,3	**5,8**	**6,7**	7,1	**7,1**	**10,9**
Male p =	,070	,102	**,016***	,052	,087	,355	,085	**,005***	**,001***	,054	**,001***	**,007***
Nc I µ	8,8	6,9	8,0	7,1	6,8	10,5	5,4	6,1	7,0	7,2	7,3	11,2
Nc II µ	8,6	6,7	7,7	7,0	6,7	10,4	5,28	5,8	6,7	7,1	7,1	10,9
Male p =	,872	,631	,915	,764	,152	,111	,805	,238	,143	,163	,094	,983
Nc III µ	8,5	6,8	7,7	7,0	6,9	10,1	5,28	5,9	6,9	7,1	7,2	11

Source for Table 4: The table shows the p-values with significance * = p ≤ 0.05 for differences in TWs when comparing the individual tooth types in the partial groups and in the subgroups.

4.3.2 Comparisons of homologous antagonistic teeth

Table 5 provides descriptive information of the mean values of TWs in the comparison of homologous antagonists in the patient pool and in the subgroups as well as analytical results according to the Wilcoxon test for significant differences.

Table 5| Description and Wilcoxon test on the TWs of homologous antagonists.

Antagonists μ and p-values	Nc	Jaws	$I_1 \leftrightarrow i_1$	$I_2 \leftrightarrow i_2$	$C \leftrightarrow c$	$P_1 \leftrightarrow p_1$	$P_2 \leftrightarrow p_2$	$M_1 \leftrightarrow m_1$
Female and male patients	**All**	μ max.	8,5	6,7	7,7	7,0	6,7	10,2
		↔ man.	5,3	5,9	6,7	7,0	7,1	10,9
		N = 182	p < 0,001*	p < 0,001*	p < 0,001*	p = 0,014*	p < 0,001*	p < 0,001*
Female patients	**I**	μ max.	8,5	6,6	7,5	6,8	6,6	10,1
		↔ man.	5,3	5,9	6,6	7,0	7,0	10,9
		N = 43	p < 0,001*	p < 0,001*	p < 0,001*	p = 0,008*	p < 0,001*	p < 0,001*
Female patients	**II**	μ max.	8,4	6,7	7,6	6,9	6,5	10,2
		↔ man.	5,2	5,6	6,5	6,8	7,0	10,6
		N = 47	p < 0,001*	p < 0,001*	p < 0,001*	**p = 0,362**	p < 0,001*	p < 0,001*
Female patients	**III**	μ max.	8,5	6,6	7,8	7,2	6,8	10,1
		↔ man.	5,3	6,2	6,8	7,2	7,2	11,1
		N = 14	p < 0,001*	**p = 0,054**	p < 0,001*	**p = 0,726**	p = 0,012*	p = 0,001*
Male patients	**I**	μ max.	8,8	6,9	8,0	7,1	6,8	10,5
		↔ man.	5,4	6,1	7,0	7,2	7,3	11,2
		N = 29	p < 0,001*	p < 0,001*	p < 0,001*	p = 0,048*	p < 0,001*	p < 0,001*
Male patients	**II**	μ max.	8,6	6,7	7,7	7,0	6,7	10,4
		↔ man.	5,3	5,8	6,7	7,1	7,1	10,9
		N = 33	p < 0,001*	p < 0,001*	p < 0,001*	**p = 0,159**	p < 0,001*	p < 0,001*
Male patients	**III**	μ max.	8,5	6,7	7,7	7,0	6,9	10,1
		↔ man.	5,3	5,9	6,9	7,1	7,2	10,8
		N = 16	p < 0,001*	p < 0,001*	p < 0,001*	**p = 0,150**	p = 0,006*	p < 0,001*

Source for Table 5: The own table shows the p-values with significance * = p ≤ 0.05 for differences in TWs in the comparison of antagonists in the patient pool and in the six subgroups.

All antagonist pairs except for four comparisons between the first premolars and one comparison between the lateral incisors differ significantly in their TWs. The only random difference in the TWs of I_2 and i_2 in the female Norma class III can be considered a typical feature for this subgroup: The TWs of teeth I_2 and i_2 in female Norma class III are generally of practically equal width. Conversely, the highly significant difference between P_1 and p_1 in female Norma class I can also be considered a typical feature for this subgroup: The TWs of the first premolars in the mandible – p_1 – are generally larger in female Norma class I than the TWs of their homologous antagonists in the maxilla – P_1 –. Testing for probabilisation between the subgroups using paired t-test (N = 6) reveals with p = 0.02 that the TWs of the first premolars are significantly less likely to differ from their homologous antagonists than the TWs of all other antagonist pairs.

4.3.3 Comparisons of neighbouring teeth in the maxilla and mandible

The neighbouring teeth were compared separately in each jaw.

4.3.3.1 Tooth width differences of neighbouring teeth in the maxilla

Table 6 shows descriptively the mean values of the TWs of neighbouring maxillary teeth in the total pool and in the six subgroups as well as analytically the results after testing with the Wilcoxon test for significant differences.

Tabelle 6I Description and Wilcoxon test of TWs of neighbouring maxillary teeth.

Neighbouring Teeth µ and p-values	Nc	Maxilla	$I_1 \leftrightarrow I_2$	$I_2 \leftrightarrow C$	$C \leftrightarrow P_1$	$P_1 \leftrightarrow P_2$	$P_2 \leftrightarrow M_1$
Female and male patients	**All**	µ mesial	8,5	6,7	7,7	7,0	6,7
		↔ distal	6,7	7,7	7,0	6,7	10,2
		N = 182	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*
Female Patients	**I**	µ mesial	8,5	6,6	7,5	6,8	6,6
		↔ distal	6,6	7,5	6,8	6,6	10,1
		N = 43	p < 0,001*	p < 0,001*	p < 0,001*	p = 0,003*	p < 0,001*
Female Patients	**II**	µ mesial	8,4	6,7	7,6	6,9	6,5
		↔ distal	6,7	7,6	6,9	6,5	10,2
		N = 47	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*
Female Patients	**III**	µ mesial	8,5	6,6	7,8	7,2	6,8
		↔ distal	6,6	7,8	7,2	6,8	10,1
		N = 14	p < 0,001*	p < 0,001*	p = 0,002*	p = 0,005*	p < 0,001*
Male Patients	**I**	µ mesial	8,8	6,9	8,0	7,1	6,8
		↔ distal	6,9	8,0	7,1	6,8	10,5
		N = 29	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*
Male Patients	**II**	µ mesial	8,6	6,7	7,7	7,0	6,7
		↔ distal	6,7	7,7	7,0	6,7	10,4
		N = 33	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*
Male Patients	**III**	µ mesial	8,5	6,7	7,7	7,0	6,9
		↔ distal	6,7	7,7	7,0	6,9	10,1
		N = 16	p < 0,001*	p < 0,001*	p < 0,001*	**p = 0,109**	p < 0,001*

Source for Table 6: The own table shows the p-values with significance * = p ≤ 0.05 for differences in TWs of neighbouring maxillary teeth in the patient pool and in the subgroups.

Analytical testing with the Wilcoxon test showed that in the maxilla, with one exception - the TWs of the premolars (P_1 and P_2) in male patients with a large mandible - all neighbouring teeth differed significantly regarding their TWs. The random TWs difference of P_1 and P_2 in male patients with a large mandible can be considered as a typical feature for male patients with a Norma class III: The TWs of the first and second maxillary premolars are practically the same width in male patients with a large mandible. No logical probability pattern in the sense of a probalisation could be identified in the maxilla.

4.3.3.2 Tooth width differences of adjacent teeth in the mandible

Table 7 shows descriptively the mean values of the TWs of neighbouring mandibular teeth in the total pool and in the subgroups as well as analytically the results after testing with the Wilcoxon test for significant differences.

Table 7| Description and Wilcoxon test of TWs from neighbouring mandibular teeth

Neighbouring teeth μ and p-values	Nc	Mandible	$i_1 \leftrightarrow i_2$	$i_2 \leftrightarrow c$	$c \leftrightarrow p_1$	$p_1 \leftrightarrow p_2$	$p_2 \leftrightarrow m_1$
Female and male patients	**All**	μ mesial	5,3	5,9	6,7	7,0	7,1
		↔ distal	5,9	6,7	7,0	7,1	10,9
		N = 182	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*
Female patients	**I**	μ mesial	5,3	5,9	6,6	7,0	7,0
		↔ distal	5,9	6,6	7,0	7,0	10,9
		N = 43	p < 0,001*	p < 0,001*	p < 0,001*	**p = 0,408**	p < 0,001*
Female patients	**II**	μ mesial	5,2	5,6	6,5	6,8	7,0
		↔ distal	5,6	6,5	6,8	7,0	10,6
		N = 47	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*	p < 0,001*
Female patients	**III**	μ mesial	5,3	6,2	6,8	7,2	7,2
		↔ distal	6,2	6,8	7,2	7,2	11,1
		N = 14	p < 0,001*	p = 0,001*	p = 0,017*	**p = 0,559**	p < 0,001*
Male patients	**I**	μ mesial	5,4	6,1	7,0	7,2	7,3
		↔ distal	6,1	7,0	7,2	7,3	11,2
		N = 29	p < 0,001*	p < 0,001*	**p = 0,078**	p = 0,007*	p < 0,001*
Male patients	**II**	μ mesial	5,3	5,8	6,7	7,1	7,1
		↔ distal	5,8	6,7	7,1	7,1	10,9
		N = 33	p < 0,001*	p < 0,001*	p < 0,001*	**p = 0,692**	p < 0,001*
Male patients	**III**	μ mesial	5,3	5,9	6,9	7,1	7,2
		↔ distal	5,9	6,9	7,1	7,2	10,8
		N = 16	p < 0,001*	p < 0,001*	p = 0,019*	**p = 0,231**	p < 0,001*

Source for Table 7: The own table shows the p-values with significance * = p ≤ 0.05 for differences in TWs of adjacent teeth of the mandible in the patient pool and in the subgroups.

Analytical testing of the TWs of adjacent teeth with the Wilcoxon test showed that in the mandible, all but five comparisons with the first premolars ($c \leftrightarrow p_1$ or $p_1 \leftrightarrow p_2$) differed significantly regarding their TWs.

In women with a small mandible, it can be assumed with significantly increased probability that the distal tooth is significantly wider than the mesial tooth in front. This probability pattern can be seen as a subgroup characteristic for women with a Norma class II.

There is also a subgroup feature in men with a medium-size mandible: Here, the TWs of the c and the p1 were only different in width by chance.

4.4 On the lateral tooth width sums [LTWSs]

Table 8 provides descriptive information on the data distribution of the lateral TWSs – $LATWS_{max}$, $LATWS_{man}$, $LPTWS_{max}$, $LPTWS_{man}$, $LOTWS_{max}$, $LOTWS_{man}$ – in the patient pool, in the genders and in the six subgroups.

Table 8l Description of the lateral TWSs in the patient pool, partial groups and subgroups.

LTWSs in mm	$LATWS_{max}$	$LATWS_{man}$	$LOTWS_{max}$	$LOTWS_{man}$	$LPTWS_{max}$	$LPTWS_{man}$
All (N=182)	22,9 ±1,2	17,8 ±0,9	46,8 ±2,1	42,9 ±2,0	23,9 ±1,1	25,0 ±1,2
Maximum =	26,2	20,0	52,4	48,2	26,4	28,6
Minimum =	19,60	14,70	41,10	36,60	20,90	21,40
Female (N=104)	22,7 ±1,1	17,6 ± 0,9	46,4 ± 2,1	42,4 ± 2,0	23,7 ± 1,1	24,8 ±1,2
Maximum =	25,5	20,0	50,6	46,9	26,4	27,6
Minimum =	19,6	14,7	41,1	36,6	20,9	21,4
Male (N=78)	23,2 ±1,3	18,1 ± 0,9	47,4 ± 2,1	43,4 ± 1,9	24,1 ± 1,1	25,3 ± 1,2
Maximum =	26,2	20,0	52,4	48,2	26,4	28,6
Minimum =	20,3	15,7	44,1	39,6	22,2	22,9
Female Nc I (N=43)	22,6 ± 1,1	17,7 ± 0,8	46,3 ± 2,0	42,7 ± 1,9	23,6 ± 1,1	25,0 ± 1,2
Female Nc II (N=47)	22,7 ± 1,2	17,3 ± 0,9	46,3 ± 2,1	41,8 ± 2,0	23,6 ± 1,1	24,5 ± 1,2
Female Nc III (N=14)	22,9 ± 1,1	18,3 ± 0,8	47,1 ± 2,1	43,7 ± 1,7	24,2 ± 1,3	25,4 ± 1,2
Male Nc I (N=29)	23,6 ± 1,3	18,5 ± 0,7	48,0 ± 1,8	44,3 ± 1,6	24,40 ± 0,7	25,7 ± 0,9
Male Nc II (N=33)	23,0 ± 1,3	17,8 ± 1,0	47,0 ± 2,4	42,8 ± 2,2	24,0 ± 1,2	25,0 ± 1,4
Male Nc III (N=16)	22,9 ± 1,3	18,0 ± 0,9	46,9 ± 2,1	43,2 ± 1,9	24,0 ± 1,1	25,2 ± 1,2

Source for Table 8: The own table shows the mean values and the first standard deviations of the lateral TWSs in the maxilla and mandible of the patient pool, in the two partial groups and in the six subgroups.

Testing the LTWSs for normal distribution using the Kolmogorov Smirnov test revealed that some of the LTWSs in the patient pool were normally distributed and others of the LTWSs were not normally distributed (**Table 9**).

Table 9l KS tests for checking the lateral TWSs for normal distribution.

Normal distribution	$LATWS_{max}$	$LATWS_{man}$	$LOTWS_{max}$	$LOTWS_{man}$	$LPTWS_{max}$	$LPTWS_{man}$
Female: *p* =	**0,001 ***	**0,001 ***	**0,001 ***	**0,030 ***	0,089	0,200
Male: *p* =	**0,006 ***	0,200	**0,010 ***	0,200	0,200	0,052

Source for Table 9: The own table shows the p-values with significance * = $p \leq 0.05$ after checking the calculated LTWSs in the maxilla and mandible for normal distribution.

The U-test revealed three main results: First: All lateral TWSs are significantly smaller in females than in males. Secondly: In women, all lateral TWSs in small mandibles are significantly smaller than in women with a Nc I or a Nc III. Thirdly: In men with a Nc I, all lateral TWSs tend to be at least significantly larger than in men with a Nc II (**Tab. 10**).

<u>Table 10</u>| U-tests of the LTWSs for differences in the partial groups and subgroups.

LTWSs µ & p-values	LATWS$_{max}$	LATWS$_{man}$	LOTWS$_{max}$	LOTWS$_{man}$	LPTWS$_{max}$	LPTWS$_{man}$
All female *(N = 104)*	22,7	17,6	46,4	42,4	23,7	24,8
♀ ↔ ♂: p all	**0,049 ***	**0,001 ***	**0,032 ***	**0,008 ***	**0,023 ***	**0,037 ***
All male *(N = 78)*	23,2	18,1	47,4	43,4	24,1	25,3
Nc III (N = 14) µ	22,9	18,3	47,1	43,7	24,2	25,4
***Female p* III ↔ I**	0,383	0,059	0,493	0,335	0,330	0,373
Nc I (N = 43) µ	22,6	17,7	46,3	42,7	23,6	25,0
NcI (N = 43) µ	22,6	17,7	46,3	42,7	23,6	25,0
***Female p* I ↔ II**	0,580	**0,039 ***	0,981	**0,023 ***	0,674	**0,026 ***
Nc II (N = 47) µ	22,7	17,3	46,3	41,8	23,6	24,5
Nc III (N = 14) µ	22,9	18,3	47,1	43,7	24,2	25,4
***Female p* III ↔ II**	0,655	**0,001 ***	0,466	**0,005 ***	0,257	**0,035 ***
Nc II (N = 47) µ	22,7	17,3	46,3	41,8	23,6	24,5
Nc III (N = 16) µ	22,9	18,0	46,9	43,2	24,0	25,2
***Male p* III ↔ I**	**0,020 ***	**0,007 ***	**0,031 ***	**0,038 ***	0,221	0,053 (*)
Nc I (N = 29) µ	23,6	18,5	48,0	44,3	24,4	25,7
Nc I (N = 29) µ	23,6	18,5	48,0	44,3	24,4	25,7
***Male p* I ↔ II**	**0,021 ***	**0,001 ***	**0,021 ***	**0,001 ***	0,066(*)	**0,006 ***
Nc II (N = 33) µ	23,0	17,8	47,0	42,8	24,0	25,0
Nc III (N = 16) µ	22,9	18,0	46,9	43,2	24,0	25,2
***Male p* III ↔ II**	0,594	0,152	0,823	0,147	0,798	0,245
Nc II (N = 33) µ	23,0	17,8	47,0	42,8	24,0	25,0

Source for Table 10: The own table shows the p-values with significance * = p ≤ 0.05 for differences in the lateral TWSs in the comparison of the two sexes and the six subgroups.

Testing for probabilisation with the paired t-test showed that the six p-values of the LATWSs comparisons in the mandible were significantly smaller (p = 0.020) than those of the LATWSs comparisons in the maxilla. The corresponding probabilisation check of the p-values for the comparisons of the LOTWSs as well as the LPTWSs showed that the LOTWSs in the mandible tended to be significantly (p = 0.063) and also the LPTWSs in the mandible tended to be significantly (p = 0.063) smaller than the p-values in the maxilla. If the LATWSs and the LPTWSs are tested simultaneously in the paired t-test (N = 12), an α-value of p = 0.002 respectively a highly significant difference is found.

4.5 On the lateral tooth width sum ratios [LTWSRs].

Table 11 provides descriptive information on the data distribution of the lateral LTWSRs - LAR, LOR, LPR - in the patient pool, in the genders and in the six subgroups.

Table 11l Description of lateral LTWSRs in the total pool, partial groups and subgroups.

LTWSRs in %	LAR	LOR	LPR
All (N = 182)	77,87 ± 2,6	91,60 ± 1,8	105,56 ± 2,7
Maximum	88,63	96,19	112,00
Minimum	68,25	84,49	97,00
Female (N = 104)	77,66 ± 2,9	91,46 ± 2,0	104,73 ± 2,9
Maximum	88,63	96,19	111,00
Minimum	68,25	84,49	97,00
Male (N = 78)	78.14 ± 2,2	91,71 ± 1,4	104,81 ± 2,7
Maximum	84,03	95,12	112,00
Minimum	72,69	88,70	99,00
Female Nc III (N = 14)	79,92 ± 3,9	92,79 ± 1,7	105,07 ± 1,9
Female Nc I (N = 43)	78,37 ± 1,9	92,28 ± 1,5	105,63 ± 2,8
Female Nc II (N = 47)	76,34 ± 2,7	90,32 ± 1,9	103,81 ± 3,0
Male Nc IIII (N = 16)	78,68 ± 2,1	92,20 ± 1,5	105,23 ± 3,3
Male Nc I (N = 29)	78,57 ± 2,5	92,20 ± 1,2	105,44 ± 2,5
Male Nc II (N = 33)	77,50 ± 1,7	91,05 ± 1,2	104,06 ± 2,4

Source for Table 11: The own table shows the mean values and the first standard deviations of the LTWSRs in the patient pool, in the partial groups and in the subgroups.

Testing the LTWSRs for normal distribution using the Kolmogorov Smirnov test (KS test) revealed that the lateral LTWSRs were generally normally distributed, with the exception of the LAR in the female patients (**Tab. 12**).

Table 12l KS-tests to check LTWSRs for normal distribution.

Normal distribution	LAR	LOR	LPR
All: *p* =	0,200	0,200	0,200
Female: *p* =	**0,019 ***	0,076	0,200
Male: *p* =	0,200	0,200	0,200

Source for Table 12: The own table shows the p-values with significance * = $p \leq 0.05$ after testing the calculated LTWSRs - LAR, LOR and LPR - for normal distribution.

Analytical testing of the LATWSRs for significant differences in the sexes and six subgroups with the Mann-Whitney test (U-test) showed that they were not significantly different between the sexes, but that when considering the entire patient pool, the LAR, LOR and LPR were highly significantly smaller in patients with small mandibles than in patients with medium or large mandibles (**Tab. 13**).

Table 13I U-tests on LTWSRs in the partial and subgroups.

LTWSRs µ & p-values	LAR	LOR	LPR
Female (N = 104) µ	77,7	91,5	104,7
All female patients ↔ male patients: p - values	= 0,148	= 0,597	= 0,916
Male (N = 78) µ	78.1	91,7	104,8
Nc III (N = 30) µ	79,3	92,5	105,3
All Nc III ↔ Nc I: p - values	= 0,173	= 0,924	= 0,342
Nc I (N = 72) µ	78,5	92,2	105,5
Nc I (N = 72) µ	78,5	92,2	105,5
All Nc I ↔ Nc II: p - values	**≤ 0,001 ***	**≤ 0,001 ***	**≤ 0,001 ***
Nc II (N = 80) µ	76,9	90,7	103,9
Nc III (N = 30) µ	79,3	92,5	105,3
All Nc III ↔ Nc II: p - values	**≤ 0,001 ***	**≤ 0,001 ***	**≤ 0,001 ***
Nc II (N = 80) µ	76,9	90,7	103,9
Nc III (N = 14) µ	79,9	92,8	105,1
Only female Nc III ↔ Nc I: p - values	= 0,247	= 0,810	= 0,312
NK I (N = 43) µ	78,4	92,3	105,6
NK I (N = 43) µ	78,4	92,3	105,6
Only female Nc I ↔ Nc II: p - values	**≤ 0,001 ***	**≤ 0,001 ***	**≤ 0,001 ***
NK II (N = 47) µ	76,3	90,3	103,8
NK III (N = 14) µ	79,9	92,8	105,1
Only female Nc III ↔ Nc II: p - values	**= 0,002 ***	**≤ 0,001 ***	= 0,145
NK II (N = 47) µ	76,3	90,3	103,8
NK III (N = 16) µ	78,7	92,2	105,2
Only male Nc III ↔ Nc I: p - values	= 0,889	= 0,997	= 0,805
Nc I (N = 29) µ	78,6	92,2	105,4
Nc I (N = 29) µ	78,6	92,2	105,4
Only male Nc I ↔ Nc II p - values	= 0,051 (*)	**≤ 0,001 ***	**= 0,033 ***
Nc II (N = 33) µ	77,5	91,1	104,1
Nc III (N = 16) µ	78,7	92,2	105,2
Only male Nc III ↔ Nc II p - values	**= 0,044 ***	**= 0,005 ***	= 0,216
Nc II (N = 33) µ	77,5	91,1	104,1

Source for Table 13: The table shows the p-values with significance * = p ≤ 0.05 for differences in LTWSRs comparing the two genders and the six subgroups.

4.6 On the comparisons with BOLTON's AR and OR

The descriptive representation of the data distribution of the LARs and the LORs in relation to the normal values and the standard deviations of BOLTON (1958) proves that in patients with small mandibles the foci of the data distribution lie below the normal values of BOLTON and in patients with medium-sized as well as large mandibles the foci of the data distribution lie above the normal values of BOLTON (**Tab. 14**).

Table 14| Description of LARs and LORs in terms of BOLTON's AR and OR.

Norma class II			Norma class I			Norma class III		
LOR	N = 80		LOR	N = 72		LOR	N = 30	
–	–		–	–		–	–	
+3. StD. BOLTON								
–	–		95,36	1		95,12 – 96,19	2	
+2. StD. BOLTON								
93,29 – 93,69	3		93,22 – 94,70	16		93,36 – 95,03	7	
+1. StD. BOLTON								
91,32 – 93,01	**28**		91,38 – 93,19	**35**		91,46 – 93,14	**14**	
Norm value BOLTON = 91,3 ± 1,9 %								
89,43 – 91,24	**34**		89,57 – 91,29	**13**		90,14 - 90,85	**7**	
-1. StD. BOLTON								
87,84 – 89,32	11		88,86 - 89,37	3		–	–	
-2. StD. BOLTON								
86,16 – 87,35	2		–	–		–	–	
-3. StD. BOLTON								
84,49 – 85,15	2		–	–		–	–	
LAR	N = 80	%	LAR	N = 72	%	LAR	N = 30	%
–	–		82,51 – 84.93	4		82,64 – 88,63	3	
+3. StD. BOLTON								
80,72 – 81,82	4		80,80 – 82,14	7		80,62 – 81.86	4	
+2. StD. BOLTON								
79,13 – 80,43	12		78,95 – 80,6	14		79,04 – 80,35	**9**	
+1. StD. BOLTON								
77,21 – 78,77	**22**		77,25 – 78,88	**26**		77,63 – 78,85	7	
Norm value BOLTON = 77,2 ± 1,7 %								
75,61 – 77,18	**28**		75,64 - 77,09	**16**		75,65 – 77,08	**4**	
-1. StD. BOLTON								
73,97 – 75,43	11		75,10 – 75,30	5		74,78 – 75,00	2	
-2. StD. BOLTON								
72,69 – 73,52	4		–	–		73,47	1	
-3. StD. BOLTON								
68,25 – 71,12	3		–	–		–	–	

Source for Table 14: The own table proves that the data centroid distribution of the LARs and LORs in the Norma classes are generally within the first standard deviation of BOLTON's AR and OR. Seven of the 182 LORs (4%) fall outside BOLTON's confidence interval and 30 of the 182 LARs (16%) fall outside BOLTON's confidence interval.

The analytical tests for significant differences between the LARs and the LORs and the norm values of BOLTON with the t-test showed that in the partial group of women and the partial group of men with small mandibles the LARs and the LORs did not differ significantly from the norm values of BOLTON (**Tab. 15**). Although there was no normal distribution for the LARs of the female patients, the t-test was used as a follow-up test for all comparisons for reasons of homogeneity of the test method in relation to a fixed standard value.

Table 15| t-tests of the LARs and LORs with respect to BOLTON's norm values.

LARs in comparison with 77.2 %	N	μ (%)	Std. Dev.	Minimum	Maximum	*p-Values*	
Female Norma class II	47	76,4	± 2,7	68,3	81,8	0,031	*
Male Norma class II	33	77,5	± 1,7	72,7	81,7	0,323	*NS*
Female Norma class I	43	78,4	± 1,9	75,2	83,0	0,001	***
Male Norma class I	29	78,6	± 2,5	75,1	84,0	0,006	**
Female Norma class III	14	79,9	± 3,9	74,8	88,6	0,021	*
Male Norma class III	16	78,7	± 2,1	73,5	81,8	0,014	*
All female patients	104	77,7	± 2,9	68,3	88,6	0,104	*NS*
All male patients	78	78,1	± 2,2	72,7	84,0	0,001	***
All patients Norma class I	72	78,5	± 2,1	75,1	84,0	0,001	***
All patients Norma class II	80	76,8	± 2,4	68,3	81,8	0,154	*NS*
All patients Norma class III	30	79,3	± 3,1	73,5	88,6	0,001	***
All patients in the entire patient pool	182	77,9	± 2,6	68,3	88,6	0,001	***
LORs in comparison with 91,3%	**N**	**μ (%)**	**Std. Dev.**	**Minimum**	**Maximum**	***p-Values***	
Female Norma class II	47	90,3	± 1,9	84,5	93,6	0,001	***
Male Norma class II	33	91,1	± 1,2	88,7	93,7	0,230	*NS*
Female Norma class I	43	92,3	± 1,5	88,9	95,4	0,001	***
Male Norma class I	29	92,2	± 1,2	89,4	94,3	0,001	***
Female Norma class III	14	92,8	± 1,7	90,7	96,2	0,007	**
Male Norma class III	16	92,2	± 1,5	90,1	95,1	0,023	*
All female patients	104	91,5	± 2,0	84,5	96,2	0,162	*NS*
All male patients	78	91,7	± 1,4	88,7	95,1	0,009	**
All patients Norma class I	72	92,2	± 1,4	88,9	95,4	0,001	***
All patients Norma class II	80	90,6	± 1,7	84,5	93,7	0,001	***
All patients Norma class III	30	92,5	± 1,6	90,1	96,2	0,001	***
All patients in the entire patient pool	182	91,6	± 1,8	84,5	96,2	0,040	**

Source for Table 15: The own table shows the p-values with significance * = $p \leq 0.05$ for differences in the LAR and LOR in relation to BOLTON's norm values for the AR and the OR. NS = No significance. BOLTON's (1958) normal value for AR is highly significantly different ($p = 0.001$) from the LAR of the patient pool and his normal value for OR is significantly different ($p = 0.040$) from the LOR of the patient pool.

4.7 On the comparisons with the AR and OR of MACHADO ET AL.

The descriptive representation of the data distribution of the LARs and the LORs in relation to the norm values and the standard deviations of MACHADO ET AL. (2020) proves that in patients with small mandibles the foci of the data distribution lie below the norm values of MACHADO ET AL (2020). and in patients with medium-sized and large mandibles the foci of the data distribution lie above the norm values of MACHADO ET AL (2020). (**Tab. 16**).

Table 16I Description of LARs and LORs in terms of the AR and OR of MACHADO ET AL.

Norma class II		Norma class I		Norma class III	
LOR	**N = 80**	**LOR**	**N = 72**	**LOR**	**N = 30**
92,51 – 93,69	**7**	92,45 – 95,36	**32**	92,79 – 96,19	**12**
+3. Std. Dev. MACHADO ET AL.					
92,19 – 92,32	2	92,19 – 92,34	4	92.20 – 92.23	3
+2. Std. Dev. MACHADO ET AL.					
92,08 – 92,13	2	91,96 – 92,03	4	91.98 – 92.01	3
+1. Std. Dev. MACHADO ET AL.					
9,81 – 91,94	6	91,75 – 91,79	2	91.81 – 91.88	3
Norm value of MACHADO ET AL. = 91,74 ± 0,20%					
91,63 – 91,70	4	91,67 – 91,72	*2*	91.46 – 91.70	2
-1. Std. Dev. MACHADO ET AL.					
91,53 – 91,36	9	91,38 – 91,53	2	-	-
-2. Std. Dev. MACHADO ET AL.					
91,14 – 91,32	4	91,15 – 91,29	4	-	-
-3. Std. Dev. MACHADO ET AL.					
91,09 – 84,49	**46**	88,86 – 91,11	**12**	90.85 – 90.14	**7**
LAR	**N = 80**	**LAR**	**N = 72**	**LAR**	**N = 30**
79,13 – 81,82	**12**	78,81 – 84,03	**28**	78,81 – 84.03	**19**
+3. Std. Dev. MACHADO ET AL.					
78,73 – 78,77	2	-	-	-	-
+2. Std. Dev. MACHADO ET AL.					
78,48 -78,51	3	78,43 – 78,45	3	-	-
+1. Std. Dev. MACHADO ET AL.					
78,30	1	78,26 – 78,37	2	78,26 – 78,32	2
Norm value of MACHADO ET AL. = 78,24 ± 0,18%					
78,17 – 78,08	3	78,07 – 78,23	4	-	-
-1. Std. Dev. MACHADO ET AL.					
77,92 – 77,98	4	77,88 – 78,05	4	-	-
-2. Std. Dev. MACHADO ET AL.					
77,83 – 77,78	3	77,87	1	-	-
-3. Std. Dev. MACHADO ET AL.					
77,67 – 68,25	**52**	75,10 - 77,68	**30**	77.69 – 73.47	**9**

Source for Table 16: The own table shows how the data centroid distribution of the LARs, and the LORs in the Norma classes all lie outside the third standard deviation of MACHADO ET AL. (2020). 133 of the 182 LORs (73%) and 156 of the 182 LARs (86%) fall outside the confidence interval of MACHADO ET AL. (2020).

The analytical tests with the t-test between the LARs as well as the LORs of the entire patient pool of this dissertation and the standard values for the AR and OR for patients with a normocclusion from the meta-analysis by MACHADO ET AL. (2020) showed that the LARs and LORs did not differ significantly from the globalised AR or OR in patients with a normocclusion (**Tab. 17**).

Table 17| t-tests of the LARs and LORs with respect to normal values of MACHADO ET AL.

LARs in comparison with 78.24 %	N	μ (%)	Std. Dev.	Minimum	Maximum	*p-Values*	
Female Norma class II	47	76,4	± 2,7	68,3	81,8	0,001	***
Male Norma class II	33	77,5	± 1,7	72,7	81,7	0,020	***
Female Norma class I	43	78,4	± 1,9	75,2	83,0	0,643	*NS*
Male Norma class I	29	78,6	± 2,5	75,1	84,0	0,475	*NS*
Female Norma class III	14	79,9	± 3,9	74,8	88,6	0,130	*NS*
Male Norma class III	16	78,7	± 2,1	73,5	81,8	0,422	*NS*
All female patients	104	77,7	± 2,9	68,3	88,6	0,042	*
All male patients	78	78,1	± 2,2	72,7	84,0	0,688	*NS*
All patients Norma class I	72	78,5	± 2,1	75,1	84,0	0,396	*NS*
All patients Norma class II	80	76,8	± 2,4	68,3	81,8	0,001	***
All patients Norma class III	30	79,3	± 3,1	73,5	88,6	0,081	*NS*
All patients in the entire patient pool	182	77,87	± 2,6	68,3	88,6	0,054	*NS*
LORs in comparison with 91,74%	**N**	**μ (%)**	**Std. Dev.**	**Minimum**	**Maximum**	***p-Values***	
Female Norma class II	47	90,3	± 1,9	84,5	93,6	0,001	***
Male Norma class II	33	91,1	± 1,2	88,7	93,7	0,002	***
Female Norma class I	43	92,3	± 1,5	88,9	95,4	0,023	*
Male Norma class I	29	92,2	± 1,2	89,4	94,3	0,056	NS
Female Norma class III	14	92,8	± 1,7	90,7	96,2	0,041	*
Male Norma class III	16	92,2	± 1,5	90,1	95,1	0,230	NS
All female patients	104	91,5	± 2,0	84,5	96,2	0,160	*NS*
All male patients	78	91,7	± 1,4	88,7	95,1	0,854	*NS*
All patients Norma class I	72	92,2	± 1,4	88,9	95,4	0,003	**
All patients Norma class II	80	90,6	± 1,7	84,5	93,7	0,001	***
All patients Norma class III	30	92,5	± 1,6	90,1	96,2	0,017	*
All patients in the entire patient pool	182	91,57	± 1,8	84,5	96,2	0,191	*NS*

Source for Table 17: The table shows the p-values with significance * = $p \leq 0.05$ for differences in the LAR and LOR in relation to the norm values for the AR and OR of MACHADO ET AL. (2020). NS = No significance. The normal value of MACHADO ET AL. (2020) for the AR differs only by chance ($p = 0.054$) from the LARs of the entire patient pool and their normal value for the OR also differs only by chance ($p = 0.191$) from the LORs of the entire patient pool.

5 DISCUSSION

The discussion comments on the evidence of this work, on the results of TWs, LTWSs and LTWSRs, and on the comparisons with the known norm values of BOLTON from 1958 and those of MACHADO ET AL. from 2020, as well as on the practical relevance of new norm values for LTWSRs.

5.1 On the evidence

The chosen study design belongs to the type of a randomised, clinical and multiple-blind pilot study verified by other norm values. Multiple blinded because neither the dentists who collected the patients, nor the patients, nor the statistician knew the aim of this work and the author was not aware of the assignments of the measurements to the Norma classes. From an evidence-based perspective, therefore, the results revealed can be described as objective and the **good objectivity** of this study can be rated just below the significance of meta-analyses (TÜRP AND ANTES, 2001). The age of the 52 female and 39 male patients was not normally distributed and averaged 17 years and 6 months for the female patients and 16 years and 5 months for the male patients. A non-normal distribution of age was to be expected, because the most frequent orthodontic treatments are carried out on patients in their second decade of life (HENRIKSON, 2000), respectively the proportion of adult patients with a desire for orthodontics is smaller than that of adolescent patients (WANGEMANN, 2008) and the lower age limit of the proband had been set at approx. 12 years - a completed change of teeth of the regular permanent dentition. This resulted in a standard deviation of the age distribution of ± 75 months for the females and ± 47 months for the males, which proves the astonishingly practical usefulness of the discrimination level *D*. With the Norma classification based on *D*, many highly significant results on differences in the comparison of the subgroups could be revealed with regard to the TWs, TWSs and TWSRs, practically independent of age. The Norma classification can therefore also be said to have **good reliability** for the period from permanent dentition on. The long-term case study on the facial angle changes (see Fig. 20) suggests that this classification can also be applied in mixed dentition II. Whether the reliability of the Norma classification is as good for mixed dentition II as for permanent dentition must be clarified in other studies.

It is possible that if the patient does not bite in IK on the lateral facial profile photograph, this may result in incorrect allocation to the Norma classes. This is because the soft tissue pogonion point [Pg'] of the mandible is positioned more distally in an open occlusion. Pg' is then further distal for two reasons: Firstly, at the initial mouth opening, the mandibular condyle slips from the IK position to the maximum retrusion position, which is on average 0.5 to 1.5 mm further distal (LEHMANN AND HELWIG, 1993), which naturally also places Pg' correspondingly further distal. Secondly, occlusal opening results in distal rotation of the mandible around the terminal hinge axis in the temporomandibular joint until it stops in a resting (floating) position at an interocclusal distance of 2-4 mm on average in the premolar region (DITTRICH, 2009). This also positions Pg' more distally. In how many cases (%) a resting (floating) position or an unusually pronounced skeletal hyperdivergence (or, on the contrary, hypodivergence) of the mandible falsifies the classification into the Norma classes must be clarified by other studies.

The null hypothesis 1 comparing the validity of the different measurement methods had to be rejected because the manual measurement is significantly more valid in measuring the maximum mesiodistal TW than the automatic measurement. This observation is not necessarily surprising because it is already known that the validity of tooth width measurements can depend on the method. For example, recent studies show that caliper measurements on plaster models can no longer be considered the gold standard because more modern measurements using 3D virtual technology have higher reliability and accuracy (FLEMING ET AL., 2011; DE LUCA CANTO ET AL., 2015; ARAGON ET AL., 2016). The measurement error analysis made here with the MF calculation according to DAHLBERG from 1940 to assess the validity of the tooth width measurement methods had produced MF values between 0.15 and 0.49 for the automatic measurement and between 0.12 and 0.22 for the manual measurement based on the quasi-random samples. In general, this attest both measurement methods for sufficiently good validity when compared with PULCER's dissertation from 2016. He determined MF values between 0.26 and 0.63 for tooth width measurement methods - CT reconstructions and 3D model scans - which were considered to be sufficiently valid. It is not clear whether the different measurement methods lead to the same results in terms of TWSRs without random chance.

5.2 On the tooth widths, tooth width sums and tooth width ratios

- *The null hypothesis 2* on the comparison of TWs of different tooth types between the different patients must be rejected because the TWs in all six subgroup comparisons of one or the other tooth type were at least tendentially significantly different in width. The only tooth type that did not differ significantly in any subgroup comparison was the upper lateral incisor, which is known to have a high variability in tooth shape (FÄSSLER, 2006). The TWs of the P_2 and those of the M_1 differed significantly more in the Norma classes than those of the I_2. Unfortunately, even with the TWs of the P_2 or M_1 teeth, the associated relative mandibular sizes - or Norma classes - cannot be determined because of the too large standard deviations.

- *The null hypotheses 3 and 4* for the comparison of the TWs of homologous antagonists or of neighbouring teeth in the same patient must be rejected because their TWs differ significantly from each other except in a few comparisons in connection with the first premolars. Why the first premolars differ less from each other than all other antagonists cannot be explained here and must be noted with amazement. The TWs comparisons of homologous antagonist teeth and neighbouring teeth revealed one typical diagnostic feature for five of the six subgroups, which did not occur in the other subgroups and could be of help in orthodontic diagnostics:

First, in female patients with medium mandibles, the TWs of the upper and lower first premolars are highly significantly different: the lower p_1 is highly significantly wider than the upper P_1 in female Norma Class I.

Secondly, in female patients with small mandibles, there is a highly significant probabilistic series in the mandible with an increase in TWs from mesial to distal: $i_1 << i_2 << c << p_1 << p_2 << m_1$.

Thirdly: In female patients with large mandibles, the TWs of antagonistic lateral incisors are practically the same width: Here, the upper lateral incisor is practically the same width as the lower lateral incisor.

Fourth: In male patients with medium-sized mandibles, the TWs of the lower lateral incisors and the lower canines are practically the same width.

Fifth: In male patients with large mandibles, the TWs of the neighbouring first and second premolars in the maxilla (P_1 and P_2) are practically the same width.

Sixthly: In male patients with small mandibles, no typical diagnostic feature in terms of TWs could be identified, which, as in all other five subgroups, only applied to them. At least it was noticeable that the first and second premolars in the mandible (p_1 and p_2) were practically the same width, which could otherwise only be observed in male class III.

These typical TWs features in the subgroups may be important for diagnostic confirmation of the Norma classes. Whether they have a therapeutic significance - e.g., for extraction therapy - must be clarified by other studies.

- *The null hypothesis 5* on the comparison of lateral tooth width sums between different patients must be rejected because the TWSs in the maxilla differ significantly in two of the six subgroup comparisons and in the mandible in four of the six subgroup comparisons. Patients with medium and large mandibles have significantly larger mandibular TWSs than patients with small mandibles. The fact that the TWSs differ significantly in the comparison between the sexes - without differentiating the size of the mandible - is less surprising, since women generally become smaller than men (KUCZMARSKI ET AL., 2002). The probabilistic comparison of the six subgroups, on the other hand, revealed the confirmation of an assumption that had previously only been given as a premise: the anterior tooth sums vary significantly in the mandible and the posterior tooth sums tend to vary significantly more in the mandible than in the maxilla. This completely new discovery is important for basic research, because if patients with medium-sized mandibles have significantly wider mandibular teeth than patients with small mandibles, but there is no difference in the maxillary tooth widths of these patients, then it is possible that other lateral cephalometric features, such as overjet, overbite, space, etc., differ in the Norma classes. This assumption should be tested in further randomised, clinically controlled and blinded studies.

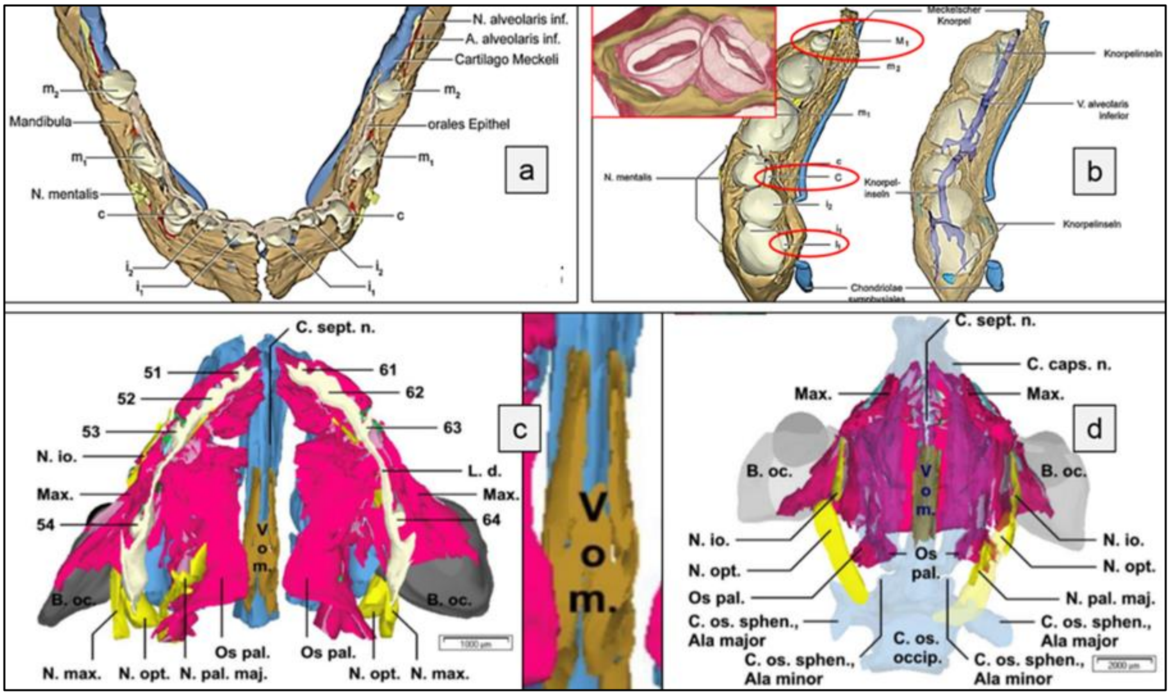
- *The null hypothesis 6* for the comparison of the lateral tooth width sum ratios [LTWSR] between different patients can only be maintained in the comparison between female and male patients if no subdivision into the Norma classes is made. In the comparison between mandibular sizes, however, it must be rejected because the LTWSRs of patients in the entire patient pool with medium and large mandibles are highly significantly larger than the LTWSRs in patients with small mandibles. This means that there is clearly a dento-facial coincidence that is more dependent on facial morphology than on gender. The cause of this is not known, which is why no speculative conjecture on the discovered phenomenon with an anthropological character is ventured here. Prospective studies in the field of anthropology may be able to reveal corresponding correlations.

Reflections on the formula premise of BOLTON:

An explanation of the discovered confirmation of BOLTON's formula premise on the basis of known studies cannot be given here because there are no clinical studies on tooth width adjustments. Therefore, only a plausible theory can be formulated here:

> The TWs in the mandible, which are genetically determined in principle, are probably more strongly epigenetically influenced by the exponential division rate of their basal bone matrix than the TWs in the maxilla because mandibular growth is less integrated into an osseous environment than maxillary growth (**Fig. 29**).

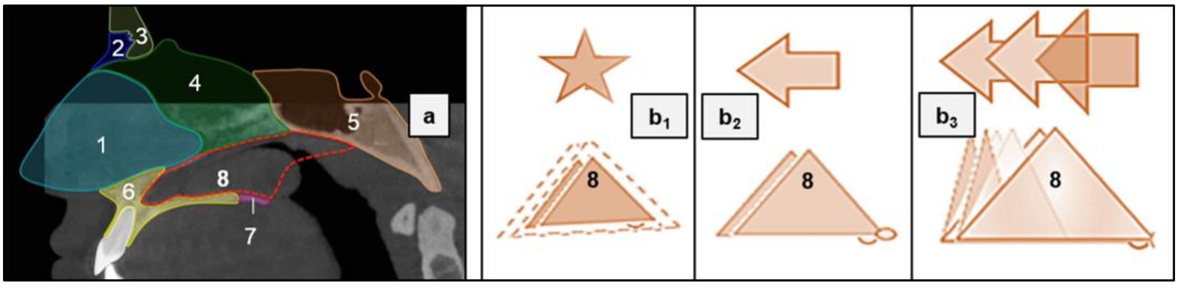
Figure 29| An overview of embryonic and fetal dentition development.



Sources for Figure 29: Figure (a) from TSENGELSAIKAN (2014) shows how, in a ten-week-old foetus, the epithelial cells have migrated from the epithelial tooth bar into the mesenchymal jaw matrix, where they have already formed recognisable deciduous tooth germs. Figure (b) from ZIMMERMANN (2014) shows the development of the dentition of a 20-week-old foetus, in which the deciduous tooth germs and the beginnings (additionally marked in red here) for the tooth germs of the permanent central incisors, the canines and the first molars have formed. An epithelial growth contact inhibition was highlighted here, which possibly occurs as soon as two neighbouring tooth germs touch each other early. Figure (c) from DIETZE (2008) shows the palatal development of a six-week-old embryo with the odontogenic epithelial ridges. In particular: The vomer is still ossifying in pairs at this time. Figure (d) from DIETZE (2008) shows the development of the nasal floor of a twelve-week-old foetus from the cranial side, with a fused secondary palate and an ossified vomer.

Theoretically, it is conceivable that the vomer - which belongs neither to the musculo-skeletal module of the maxilla nor to that of the mandible - could be a growth structure typical for a certain ethnic population but laterally differentiated: In the foetus, its lamellae block each other in growth towards the median and are - as is suspected here - thus also controlled in growth towards the cranial, lateral, caudal and posterior embryonal or early foetal in an individually different way. It could be that the vomer does not grow equally strongly sagittal on both sides. This could lead to the maxilla side in front of it with its odontogenic epithelial ridge becoming more or less advanced, which then leads laterally to different angle classes. In this case, the odontogenic epithelial ridges would only be indirectly influenced by the advancement of the vomer and would be less stretched, which would explain more constant TWs overall in the maxilla than in the mandible (**Fig. 29c and 30**).

Figure 30| A theory on the growth influence of the vomer.



Sources for Figure 30: Figure (a) from YAN ET AL. (2018) proves the location of vomer (8) in relation to the other chondral and osseous structures: (1) cartilago septi nasi, (2) os nasale, (3) os frontale, (4) lamina perbendiculare of os ethmoidale, (5) os sphenoidale, (6) maxilla, (7) os palatinale, (8) os vomer. The own schematic figures (b_1) to (b_3) schematically show the thought model on the theoretical growth influence of the vomer on the maxillary sides surrounding it: Scheme (b_1) represents the embryonic vomer situation, when the two lamellae still consist of their pluripotent cartilage cells, which are genetically determined in number, and can grow relatively independently of their surroundings. Scheme (b_2) represents an early fetal vomer situation when the vomer lamellae already co-define the shape of the vomer through support ossification [desmal ossification] and grow mesially as dictated by the environment. Scheme (b_3) represents a fetal vomer situation when the vomer lamellae have undergone several cell division cycles and are environmentally pre-growing before desmal ossification of the vomer lamellae begins and the vomer shape is then largely defined. If the desmal ossification of one side begins several cell division cycles earlier than in the other lamella, then - as is assumed here - an asymmetrical situation in the naso-maxillary complex should result with practical effects on the relative sagittal position of the teeth.

The theoretical lines of thought on an asymmetrical vomer growth cluster are difficult to verify. This is mainly because the nasal septum is anterior to the vomer. LATHAM observed in 1971 that the wedge-shaped tip of the vomer gradually slides under the cartilaginous nasal septum in the course of embryonic development. Therefore, it is conceivable that a fetal growth disturbance of the nasal septum could laterally deflect the remaining growth potential of the vomer, leading to differential elongation or even compression of the odontogenic epithelial crest frontally and ultimately to differential TWs of the mammary incisors. This in turn could possibly explain the increased shape variability of the lateral permanent incisors.

The regular shape and size of the nasal septum seems to be less the causative reason for different maxillary expressions, as is assumed here, because variations of the nasal septum are common in the ostiomeatal facial complex of adult humans and deviations or pneumatization of the vomer are an exception (JYOTHI ET AL., 2013).

It is therefore advisable to examine patients with ethnically different midfaces - the shape of the nose plays less of a role, as is assumed here - in isolation.

The vomer module, with its presumably genetically determined number of pluripotent stem cells, could possibly alter the variability of the upper tooth widths in the case of gene defects or gene variations, as the following circumstantial evidence suggests:

First, the vomer may be too small along with other bones in the nasal facial region, as occurs in patients with osteogenesis imperfecta [OI]: In individuals with OI, bone formation in the maxilla is more embryonically suppressed than that in the mandible (NGUYEN ET AL., 2017), possibly resulting in unusual LTWSRs.

Secondly, the vomer may be too large, as demonstrated by KYLE ET AL. (1992) on the aetiology of cleft lip, jaw and palate [CLJPs]: they revealed that a vomer that has grown too much in volume between the 8th and 21st week of gestation coincides with the formation of cleft lip, jaw and palate [LKG cleft] and maxillary hypoplasia, possibly leading to unusual LTWSRs depending on the extent of the LKG cleft.

Thirdly, the shape of the vomer assumes an important functional role as the base of the nasal septum and osseous guidance structure of the bilaterally formed nasal cavity because of prospective breathing (MOONEY ET AL., 1992; DIETZE, 2008), possibly leading to unusual LZBSVs depending on ethnic origin.

Only the considerations made here about the Vomer show that the confirmation of BOLTON's formula premise (1958) is a discovery which can be noted with amazement at the present time but cannot be conclusively explained.

5.3 On BOLTON's norm values

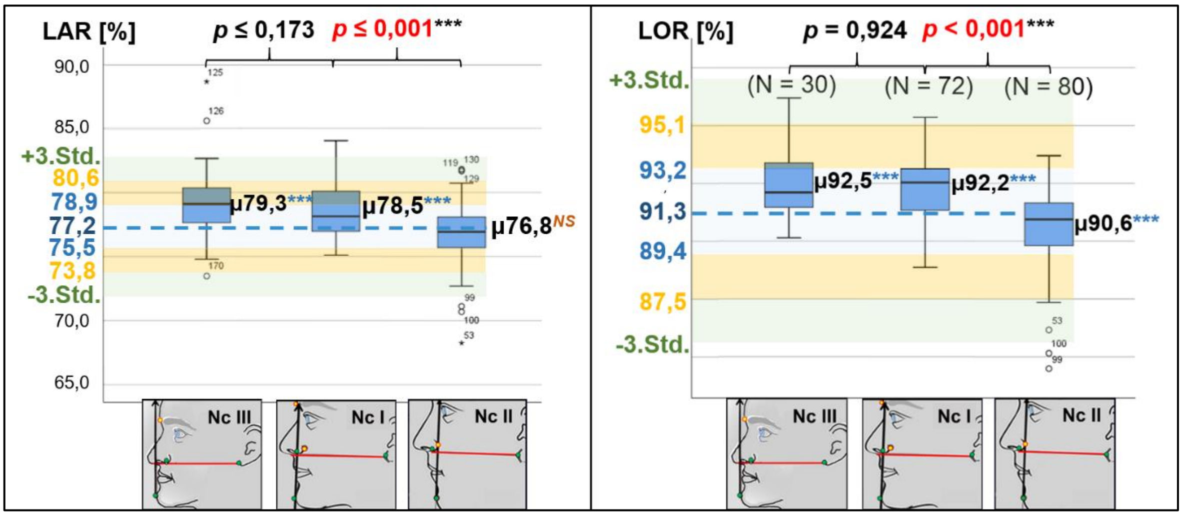
To the best of our knowledge, this is the first research comparing lateral TWSRs in three different mandibular sizes in individuals with malocclusion with BOLTON's norm values (1958) and MACHADO ET AL.s (2019) norm values without radiographs.

- The *null hypothesis 7* for comparison with BOLTON's norm values can only be maintained in the case of female patients - a subgroup consisting of all three Nc subgroups - as well as male patients with small mandibles - one Nc subgroup. In relation to the entire patient pool, it is rejected.

There are authors who, due to the fact that in the 1960s more female than male patients were generally treated orthodontically, are of the opinion that BOLTON received mainly female models for his data pool (PROFFIT, 1994; OTHMAN AND HARRADINE, 2006). The results presented here can confirm this view, although it can be speculated that there may well have been male patients who had a small mandible in the majority of cases. This is because the male patients with a medium and large mandible differ significantly from BOLTON's normal values for the AR and the OR. It is a speculative precision because it is unlikely that BOLTON's 44 treated cases had compensation curves that did not differ from the 11 untreated cases. This means that BOLTON 1958 almost certainly had multiple selection bias in his analysis.

At least the range of values for the LAR and LOR in this randomised study largely matched that for the AR in the study by BOLTON (1958) (**Fig. 31**).

Figure 31| The box plots of the LARs and LORs in relation to BOLTON's data distribution.



Source for Figure 31: The own figure shows a graphical comparison of the data distribution of the LAR and the LOR in the Norma classes in comparison with the mean values for the AR and the OR of BOLTON (1958). It also shows the highly significant differences *** of five of the six subgroups to his norm values. Only the subgroup of LAR in patients with a Norma class II did not differ significantly (*NS*) from BOLTON's norm values.

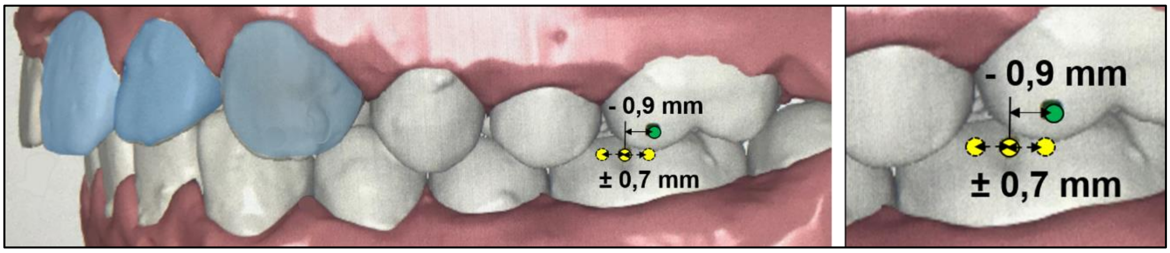
If BOLTON's 1958 results on overbite are also included in the discussion, then the suspicion arises that his models, with a mean value of 31.2%, had the character of a slight deep bite in terms of overbite, when compared, for example, with the experience of WICHELHAUS and EICHENBERG (2013). RAKOSI and JONAS (1989) also speak of a deep bite from an overbite of more than 3 mm. How, for example, the overbite presents itself in patients with a large mandible or how the angle classes coincide with the Norma classes must be clarified in other studies.

Why the analysis of BOLTON (1952) was originally not carried out laterally separated can actually only be explained by the lack of access to information through the internet and by the lack of modern measuring aids, because it was already known in 1944 that homologous right and left teeth differ by more than 0.25 cm in 90% of cases (BALLARD, 1944).

It is also unclear why there are studies that find significant differences in AR and OR in the three Angle classes (TA ET AL., 2001; ARAUJO AND SOUKI, 2003) and there are studies that cannot find significant differences in the three Angle classes, whether the sexes are tested separately (BASARAN ET AL., 2006) or not separately (CROSPY AND ALEXANDER, 1989).

Is there possibly a bias hidden in the assignment to the Angle classes, which is related to the TWSRs? There are at least some authors who think that the sagittal position classification of the first molars according to ANGLE (1899) as the most original cephalometric feature does not have a particularly good discriminatory ability (RINCHUSE, 1989; KATZ, 1992; LUI, 2017) (**Fig. 32**).

Figure 32| Insufficient discriminatory power of the Angle classes as scientific bias.



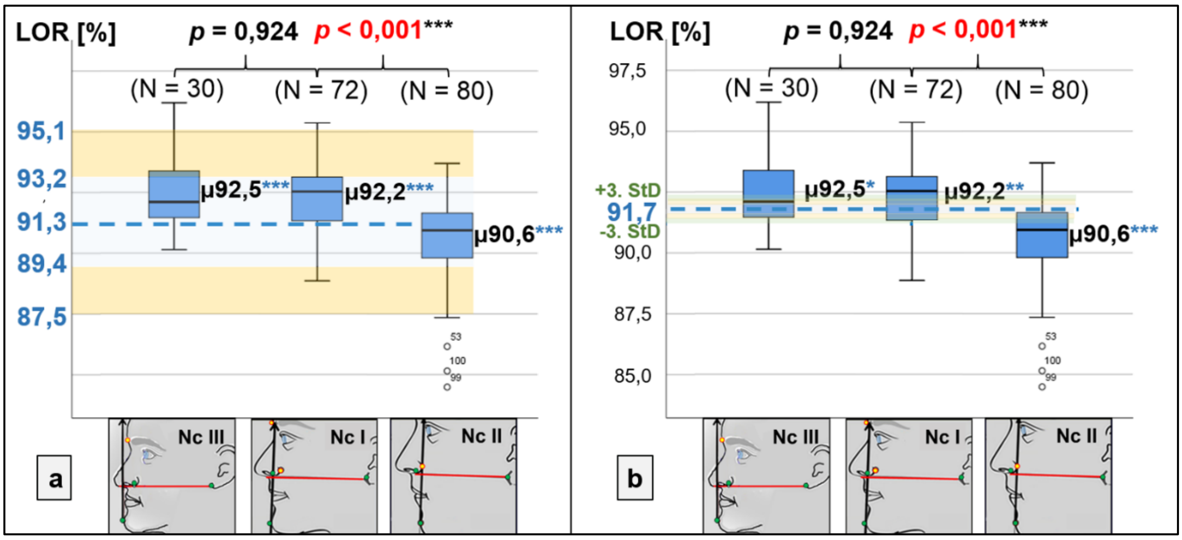
Sources for Figure 32: The own figure - a labelled and a coloured screenshot of a 3D scan (SW2.0®, Primescan™, SIRONA, D) - shows an OR of 95.2%. This OR resulted from a TWS of 43.8 mm in the mandible and a TWS of 46.0 mm in the maxilla. The TWs of the right and left first molars [M_1] are relatively small here with 9.2 mm ± 0.2 mm and the TWs of their homologous antagonists [m_1] are relatively wide here with 11.9 ± 0.2 mm. All other teeth occlude here in an excellent occlusion. Because the SW2.0® software defines the range for an Angle Class I as ± 0.7 mm, it declares an Angle Class III for this dental arch. This malocclusion and TWs disharmony is caused by the TWs variability of the first molars and the question arises, would orthodontists also diagnose a Class III here?

Although its discriminatory power is questionable, the Angle Classification cannot be explained away because it is the historical basis of orthodontics. Nevertheless, it is rather of an academic nature because it can hardly be recognised by the patient himself by means of a mirror. With today's modern dento-facial findings, it is more of a finding than an initial diagnosis (see Fig. 3 and Fig. 4). For purely pragmatic reasons, the most striking anterior tooth finding is more suitable as an initial diagnosis.

The present results lead to the assumption that white male patients with a medium or large mandible and a malocclusion are less likely to be treated (too easily or too difficult) in such a way that their treatment result fits the requirements of the American Board of Orthodontics for an excellent tooth position of the Angle Class I type in the region of the first molars and therefore these patients are less likely to be considered in studies such as that of BOLTON (1958) or ALAMIR (2013) than all other patients.

- *The null hypothesis 8* for comparison with MACHADO ET AL.'s norm values is retained. The globally determined norm values for the OR and AR of MACHADO ET AL. (2020) for patients with natural norm occlusions do not differ significantly from the LARs and LORs of the entire patient pool of malocclusions. Thus, a natural normocclusion can only be considered a "golden" special case of malocclusion, which is only significantly noticeable after "discrimination" into the gender-unspecific Norma classes (**Fig. 33**).

<u>Figure 33l</u> The box plots of the LORs with respect to BOLTON's and MACHADO ET AL.'s OR.



Source for Figure 33: The own figures (a) and (b) illustrate graphically with box plots how the LORs after a refined division into the three Norma classes differ highly significantly *** from the norm values for the OR of BOLTEN (1958) (a) and at least significantly * from those of MACHADO ET AL. (2019) (b).

In terms of diagnostics, it should be noted that none of the proband had given a directly or indirectly acquired cause for the malocclusions in their medical history. Also, none of the subjects had reported temporomandibular joint disorders. If the confidence interval of MACHADO ET AL. (2020) is considered as the decision range for still naturally favourable normocclusions, then only just 14% of all LARs were suitable for setting a natural normocclusion.

Orthodontists should be aware of this fact and, in addition to the easy-to-make anterior diagnosis, should also objectify the LTWSRs, because if they cannot recognise the limits of the therapy options towards a natural normocclusion, then they will be treating for years towards a therapy goal that they can never achieve.

Although the studies by BOLTON (1958) and ALAMIR (2013) had shown that approx. 95% of the LOR examined lay within their confidence interval and could thus possibly also be converted into an excellent normocclusion, the results of BOLTON and ALAMIR were mainly due to cases selected by hand, which - as is assumed here - can only be protected from recurrence with appropriate retention aids.

Further studies should also be carried out on other ethnic groups to check whether the norm values for the LAR, LPR and LOR determined here have global validity in the Norma classes (**Tab. 18**).

Table 18| Normal values for the LAR, LOR and LPR in the Norma classes.

Laterale Anterior Ratio in %	N	μ	Standardabweichung	Minimum	Maximum
Norma Klasse II	80	**76,8**	± 2,4	68,3	81,8
Norma Klasse I	72	**78,5**	± 2,1	75,1	84,0
Norma Klasse III	30	**79,3**	± 3,1	73,5	88,6
Laterale Posterior Ratio in %	**N**	**μ**	**Standardabweichung**	**Minimum**	**Maximum**
Norma Klasse II	80	**103,9**	± 2,8	97,0	110,0
Norma Klasse I	72	**105,6**	± 2,7	99,0	111,0
Norma Klasse III	30	**105,2**	± 2,8	99,0	112,0
Laterale Overall Ratio in %	**N**	**μ**	**Standardabweichung**	**Minimum**	**Maximum**
Norma Klasse II	80	**90,6**	± 1,7	84,5	93,7
Norma Klasse I	72	**92,2**	± 1,4	88,9	95,4
Norma Klasse III	30	**92,5**	± 1,6	90,1	96,2

Source for Table 18: The own table summarises the gender-unspecific pilot norm values for the LAR, LOR and LPR in the three Norma classes.

The practical relevance of the norm values evaluated here for the LOR in patients with malocclusion is difficult to assess because they compare the TWs from relatively many TWs at the same time. Possibly useful for the rationale for shifting whole dentition. This has to be confirmed or denied by first prospective case reports.

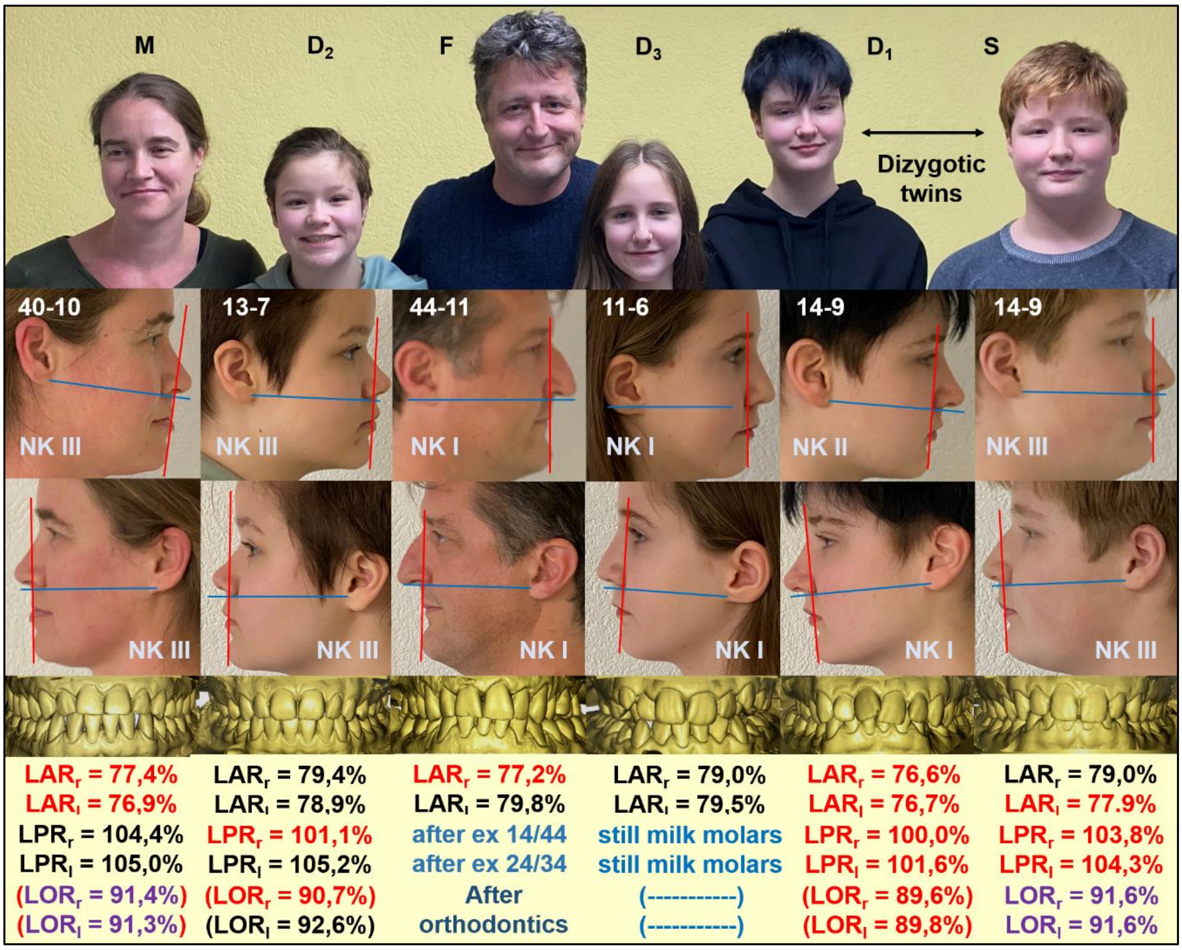
The LPR are rather of academic nature because of their large standard deviations. Perhaps they have a practical relevance in the case of extraction planning.

On the other hand, the LAR can be used very well for anterior diagnoses because, together with the Nc's, they offer the patient a plausible explanation for the crowding in the mandible, which can be illustrated, for example, with a case presentation based on a spontaneously recorded extended family (see next Chapter 5.4).

5.4 On the practical relevance of new standard values for TWSRs

The practical usefulness of new norm values for TWSRs in malocclusion after classification into a Norma class is discussed on the basis of findings using photography (iPhone 12^{TM}, APPLE, USA) and intraoral scanning (Primescan^{TM}, SIRONA, D) in a spontaneously recorded extended family (December 2020) (**Fig. 34**).

Figure 34| Dento-facial overview diagnostics for an extended family.

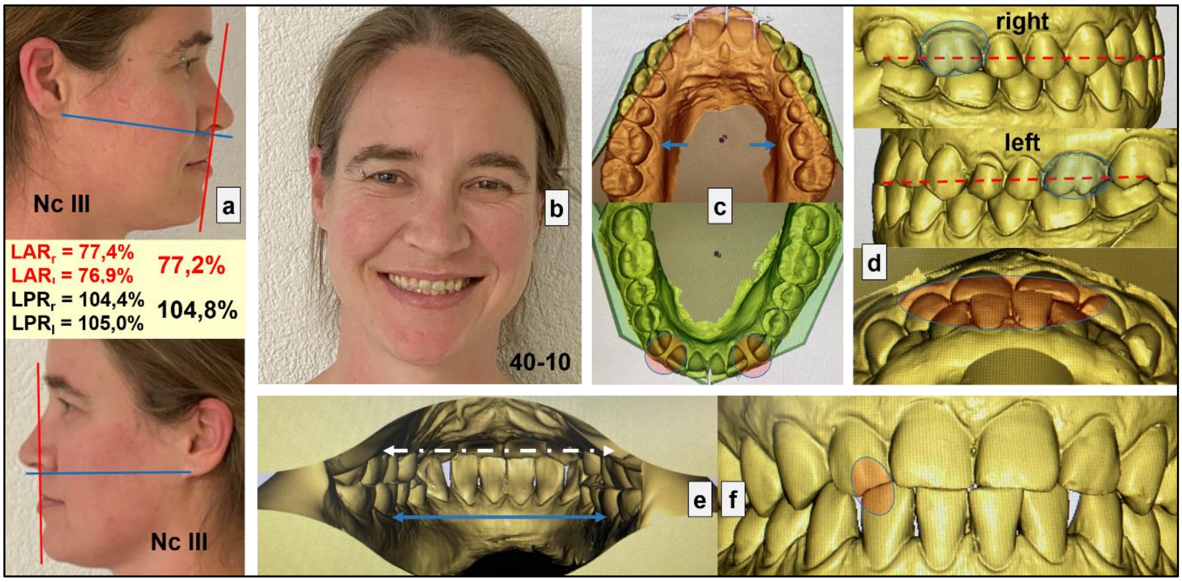


Source for Figure 34: The own figure presents the relative mandibular sizes, anterior diagnoses and calculated TSWRS in an extended family: The mother (M) has a frontal head bite, small LARs and large LPRs with a large mandible. The second daughter (D_2) has a frontal horizontal open bite, large LARs, small LPRs on the right and large LPRs on the left with a large mandible. The father (F) has an upper midline shift with a medium sized mandible and small LARs on the right but large LARs on the left. The third daughter (D_3) has ectopic upper canines and large LARs in a medium sized mandible. The first daughter (D_1) has a small mandible on the right and a medium sized mandible on the left, nested upper incisors and small LARs and LPRs on both sides. Her fraternal twin brother (S) has a large mandible with a frontal deep bite, large LARs on the right and small LARs on the left and small LPRs on both sides.

Sadly, more dento-facial information is needed to recognise causal relationships:

The mother joins in here for the completeness. She has a frontal head bite. Her LAR_r = 77.4% and LAR_l = 76.9% fit persons with small mandibles. These LARs explain the tooth gaps in the lower anterior region: The probabilisation on the TWSs had revealed that the lower TWSs vary significantly more in the mandible than in the maxilla, which is why it is assumed here that the lateral lower anterior sums are too small: The incisors only insufficiently come under their antagonists in the upper jaw (Fig. 35).

Figure 35l Dento-facial diagnostic for the mother.

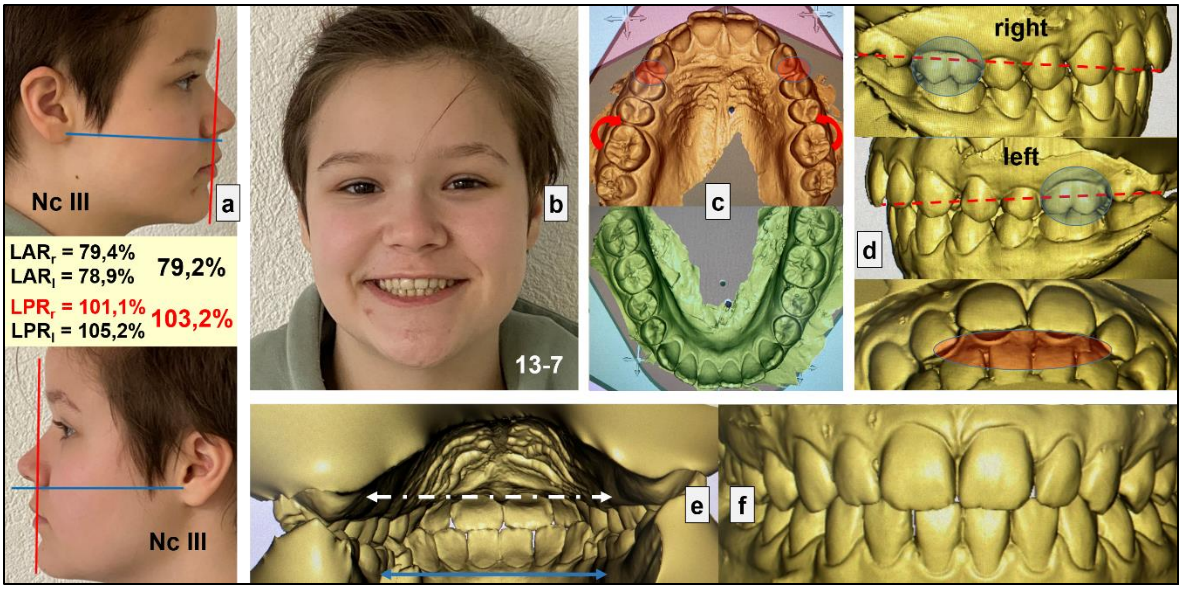


Source for Figure 35: The own figure shows with the figure (**a**) the mother with a bilateral Norma Class III as well as too small LARs, which would rather fit patients with small mandibles. Figure (**b**) shows the mother's rather broad face type. Figure (**c**) shows her permanent dentition with almost perfect alignments and anterior gaps mesial to the lower canines. Figure (**d**) shows an Angle Class I on the right and left side, a deepened compensation curve and a frontal head bite. Figure (**e**) shows her rather flat palate and matching apical bases in the 6 region. Figure (**f**) shows a largely symmetrical anterior view with crossbite between tooth 12 and tooth 42.

A therapy suggestion: The result of a pure orthodontic therapy would probably become unstable over time without a simultaneous enlargement of the lower incisors. The frontal head bite could be corrected, for example, with an aligner - Invisalign system (Align Technology, USA) (SCHUP, 2010). For aetiological reasons, the lower anterior teeth should be enlarged by tooth augmentation in order to secure the corrected headbite situation and to close the gaps. However, the mother did not want the incisors to be enlarged and did not want retainers either, so nothing was done in the end.

The second daughter sucked her thumb until the age of 10. She has a frontal horizontal open bite, which may have been caused by the previous habit, because her large LARs - caused by relatively wide lower anterior teeth - in combination with a lateral Angle Class I dentition of the molars does not suggest a horizontal open bite (**Fig. 36**).

Figure 36| Dento-facial diagnostic for the second daughter.

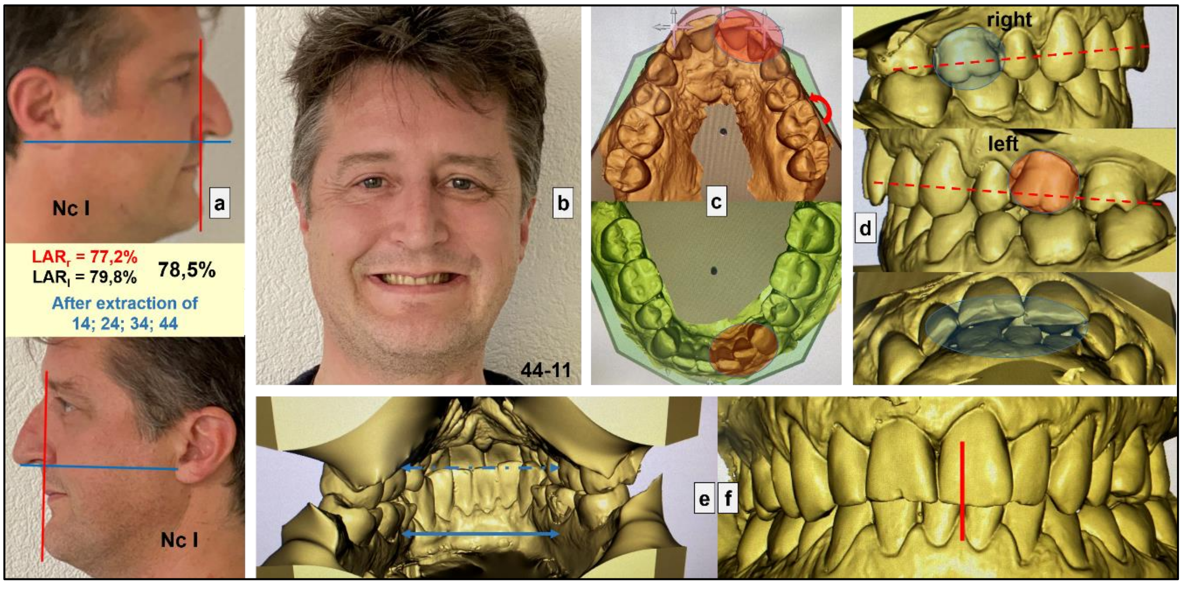


Source for figure 36: The own figure shows with figure (**a**) the second daughter with a bilateral Norma class III as well as bilateral large LARs. The overall PR fits individuals with small mandibles and is based on smaller lower posterior teeth. Figure (**b**) shows her rather broad facial type. Figure (**c**) shows her permanent dentition with almost perfect alignments with slightly mesially rotated teeth 16 and 26 and small gaps distal to 13 and 23. Figure (**d**) shows an Angle Class I of the molars and unsupported maxillary incisors (horizontal open bite) on both sides as well as a deepened compensation curve. Figure (**e**) shows a rather flat palate and matching apical bases in the 6 region. Figure (**f**) shows an appealing largely symmetrical anterior tooth view.

A therapy suggestion: A stretching of the upper dental arch - to retract the maxillary front (BACHER, 2019) - with distal rotation of teeth 16 and 26 would be a reasonable therapy path here, if the average posterior ratio did not suggest that the posterior teeth in the mandible are relatively small. Therefore, the second daughter was only recommended the placement of a retainer for the upper central incisors without previous orthodontics. In the end, nothing was done for the time being because the still existing growth potential together with the lip pressure could possibly reduce the open bite of the incisors on their own. The situation of her teeth will be re-evaluated in one year.

The Father had orthodontics for eight years in his youth with extraction of the four first premolars and he is unhappy because of the relapse. He has an upper midline shift. On the right, his LAR_r = 77,2% fits patients with small mandibles although he has a Norma Class I. On the left, his LAR_l = 79.8% fits patients with large mandibles although he also has a NK I there. Both LARs match the space balance in the lower anterior region: On the right it is more balanced and on the left it is negative - the too wide teeth lack space - (**Fig. 37**).

Figure 37| Dento-facial diagnostic for the father.



Source for Figure 37: The own illustration shows with the figure (**a**) the father with a bilateral Norma class I as well as too small LARs on the right and too large LARs on the left. Figure (**b**) shows the father's rather narrow face type. Figure (**c**) shows his permanent dentition with good alignments on the right, a frontal crowding on the left and a mesially rotated tooth 26. Figure (**d**) shows an Angle class I on the right and an Angle class II on the left, supported anterior teeth and a deepened Spee curve. Figure (**e**) shows his high palate with just matching apical bases in the 6's region. Figure (**f**) shows a midline shift to the right, although this laterality was caused by tooth 26 being tipped into an Angle class II on the left (16 is more orthogonal in an Angle class I) rather than the different LARs.

A therapy suggestion: The records of the previous orthodontic treatment cannot be found, which is why the extent of the recurrence cannot be estimated and it remains unclear whether the periodontal recessions are a consequence of the therapy. The anterior crowding is certainly the result of recurrence because retainers have been missing for years. Retainers should remain in place for life to prevent relapse (LANG ET AL., 2002; LITTLEWOOD ET AL., 2006; MELROSE AND MILLETT, 1998). For periodontal reasons, re-therapy was not advised.

The situation with the father gives the impression that the extraction of the four first premolars was a wrong decision. Was the extraction decision based on BOLTON's norm values? This can only be speculated because of the missing initial documents. Even today, extraction therapy is a matter of pure discretionary matter.

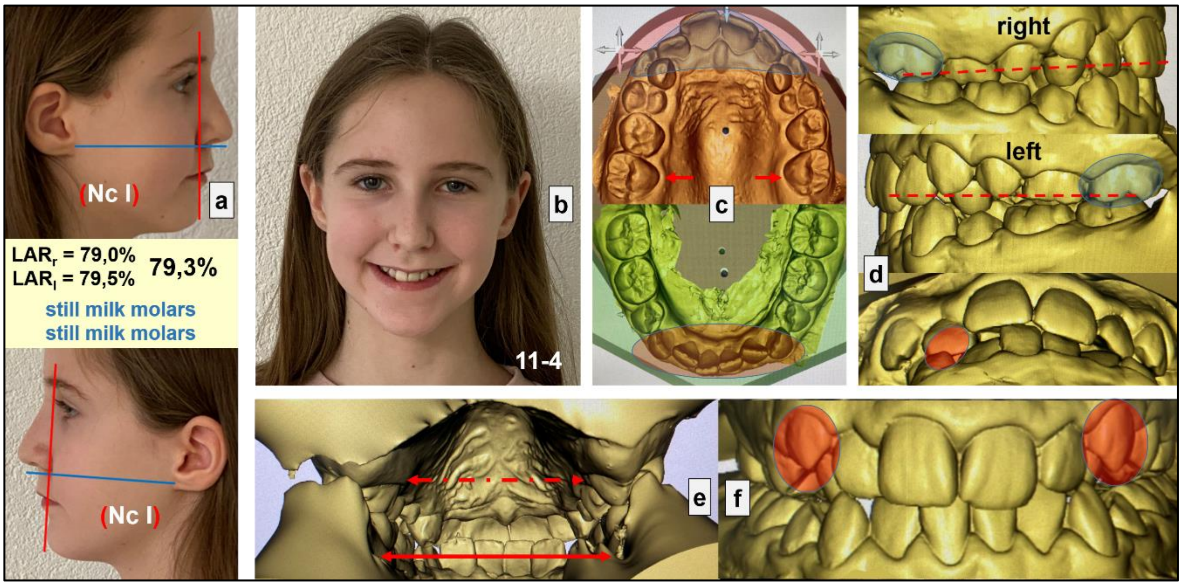
In principle, E.H. ANGLE belonged to the "non-extractionists", which is why it took a few years before the first supporters of tooth extractions spoke out. One of the first advocates in support of orthodontics with previous extraction of four premolars was TWEED (1944). TWEED - a former student of ANGLE - estimated that only 20% of his clinical cases treated without tooth extraction resulted in a successful outcome (TWEED, 1944).

In the meantime, there are various successful case presentations with extraction of the four first premolars, for example, a work by MARTINS DE ARAUJO AND DUARTE CALDAS (2019) or extraction of the four second premolars (MASCARENHAS ET AL., 2018) or extraction of the lower first premolars in combination with the first molars in the maxilla (FIORILLO, 2019) or other successful extraction cases. In addition to case presentations, retrospective studies of extraction cases can also be found, such as the work of CHEN ET AL. (2010). They investigated the positional changes and movement pattern of incisors and molars after orthodontic treatment with extractions of all four second premolars in patients with mild crowding in an Angle class I. According to RUELLAS ET AL. (2010), the extraction of premolars is indicated in cases of pronounced crowding or unilateral agenesis, among others. In this context, the extraction of upper premolars should be well considered because it can make the face more concave, which is of clinical importance especially in Angle class III ("large mandibles") (LO GUIDICE ET AL., 2020).

Of the above-mentioned authors on the subject of extraction, only MARTINS DE ARAUJO AND DUARTE CALDAS (2019) took BOLTON's standard values for the AR - but not those for the OR - into account in their extraction decision. The other authors did not mention BOLTON's 1958 OR and AR at all. However, according to OTHMAN AND HARRADINE (2006), these should be considered because they can be used to legitimise stripping, tooth reshaping and extraction.

The third daughter is annoyed about her milk canines. She has two ectopic upper canines. Her LARs fit to large mandibles which explains the frontal crowding in her medium sized mandible - the large teeth lack space - (**Fig. 38**).

Figure 38l Dento-facial diagnostic for the third daughter.

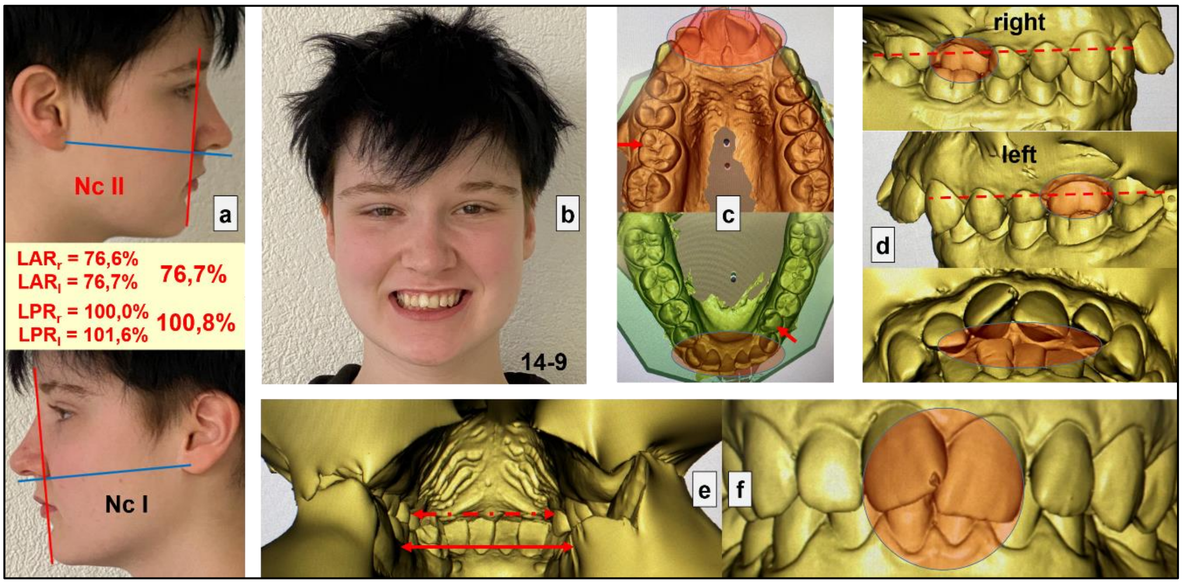


Source for figure 38: The own figure shows with figure (**a**) the third daughter with bilateral medium sized mandibles and large LARs. Figure (**b**) shows her rather narrow face type. Figure (**c**) shows her alignments in the mixed dentition of the deciduous canines and molars with slightly buccally tilted teeth 16 and 26 and a bimaxillary frontal crowding. Figure (**d**) shows an Angle class I on the right and left as well as a head bite between tooth 12 and tooth 43 and an already deepened compensation curve. Figure (**e**) shows her slightly high palate and a relatively small apical base in the region of the upper first molars. Figure (**f**) shows an upper anterior position with ¾ of the canines erupted.

A therapy suggestion: In the third daughter, the transversal crossbite in the primary teeth already indicates that the maxillary base will also be relatively narrow for permanent dentition. The lack of space in the anterior region has already manifested itself. Crowding in the mandibular anterior region is relatively common with permanent dentition (PROFFIT, 1998) because teeth physiologically push mesially throughout life (VILLARD, 2014), which does not mean that anterior teeth that are not too wide could be the main reason for crowding. Her relatively large mandibular anterior teeth have only been in place for a few years and her LARs may explain the crowding. She is waiting for the complete permanent dentition because otherwise she would have to walk around with braces for an unnecessarily long time. The milk canine teeth are already highly mobile, and the patient will extract them herself. The situation of her teeth will be re-evaluated in one year.

The first daughter adapts her hairstyle to the position of her teeth. She has a crowding of the upper incisors. Her small LARs match the small lower jaw on the right. Nevertheless, she has a lower anterior crowding, which is probably due to the tapered alignment rather than the small TWs (**Fig. 39**).

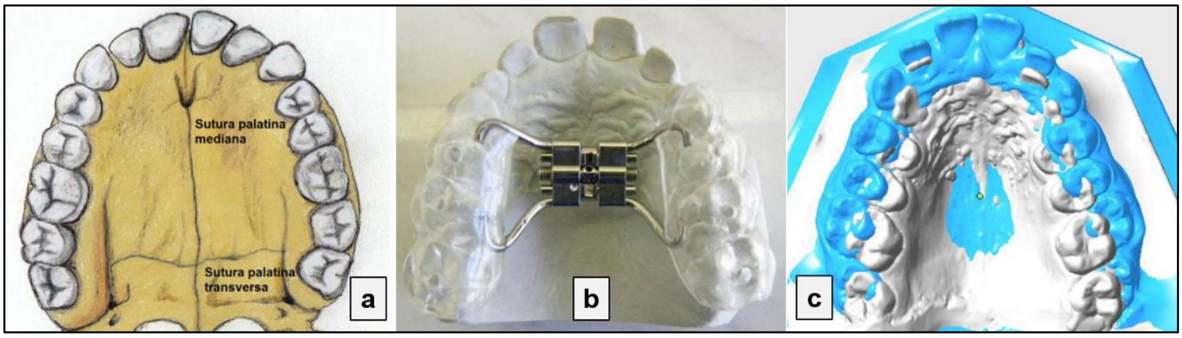
Figure 39| Dento-facial diagnostic for the first daughter.



Source for figure 39: The own figure shows with figure (**a**) the first daughter with a small lower jaw on the right and a medium sized lower jaw on the left, as well as LARs and LPRs, which fit small lower jaws. Figure (**b**) shows her rather narrow face type. Figure (**c**) shows her alignments in permanent dentition, with orally displaced teeth 16 as well as 34 and crowding in the anterior regions (larger in the maxilla than in the mandible). Figure (**d**) shows a Class II tending angulation on the right and a typical Class II/1 on the left with unsupported anterior teeth and a deepened compensation curve. Figure (**e**) shows her relatively high palate and a transversely too small apical base in the region of the upper first molars. Figure (**f**) shows central incisors with crowding and a deep bite.

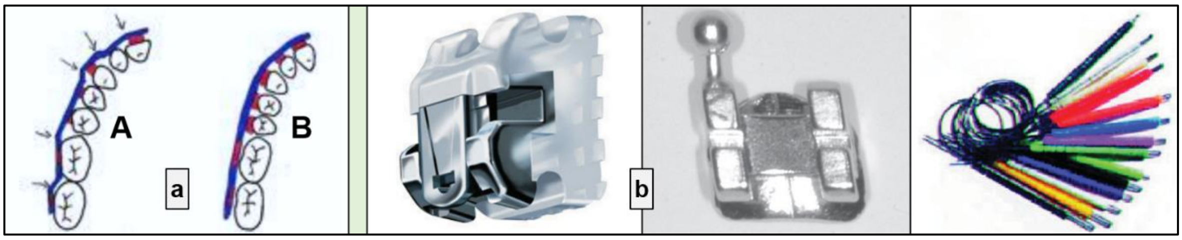
A treatment proposal: She receives a fixed palatal expansion appliance [pea] (**Fig. 40**) with centre of action in region 16. Then teeth 15 and 25 are extracted. Fixed straight-wire appliances are then inserted to adjust the alignments (**Fig. 41**). The gap is closed in regions 15 and 25, respectively, by moving teeth 14 ↔ 16 and 24 ↔ 26 against each other, and then the anterior block is distalised (**Fig. 42**). In the mandible, the anterior teeth are reduced interproximal by stripping (wider contact surfaces). Thus, the TWs of the extracted teeth are compensated for by mesialisation of teeth 16 and 26 and a reduction of the lower anterior teeth in terms of the TWSRs. Retainers in the maxilla and mandible should then secure the result.

Figure 40l The therapeutic principle of the palatal expansion appliance.



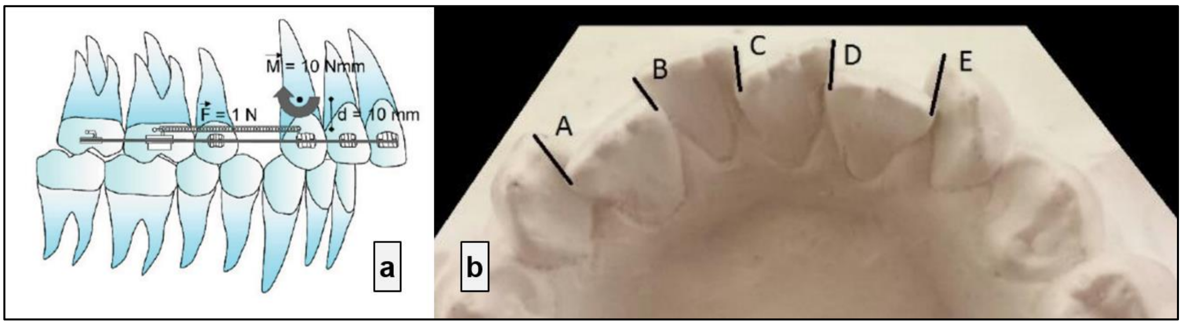
Source for Figure 40: Figures (**a**) to (c) from VAN SCHÖLL (2017) show the maxillary sutura palatina mediana being expanded in Figure (**a**). Figure (**b**) shows a removable palatal expansion appliance [pea], which is worn 24 hours a day, especially during growth, usually for six weeks. There are also fixed pea which usually widen the palate within two weeks by forced expansion; these are known to improve nasal breathing as well (BÖSSNER, 2006). Figure (**c**) shows two superimposed upper jaw models (t_0 white and t_1 blue) of a patient in permanent dentition before (t_0) and after (t_1) the effect of a pea.

Figure 41l The straight-wire technique.



Sources for Figure 41: Figure (**a**) from MÜLLER (2017) shows the therapy principle of the standard Edgewise technique (A) (ANGLE, 1928) and the straight-wire technique (B) (ANDREWS, 1978). Figure (**b**) from GÜRLER (2008) shows two straight-wire brackets and elastic ligatures.

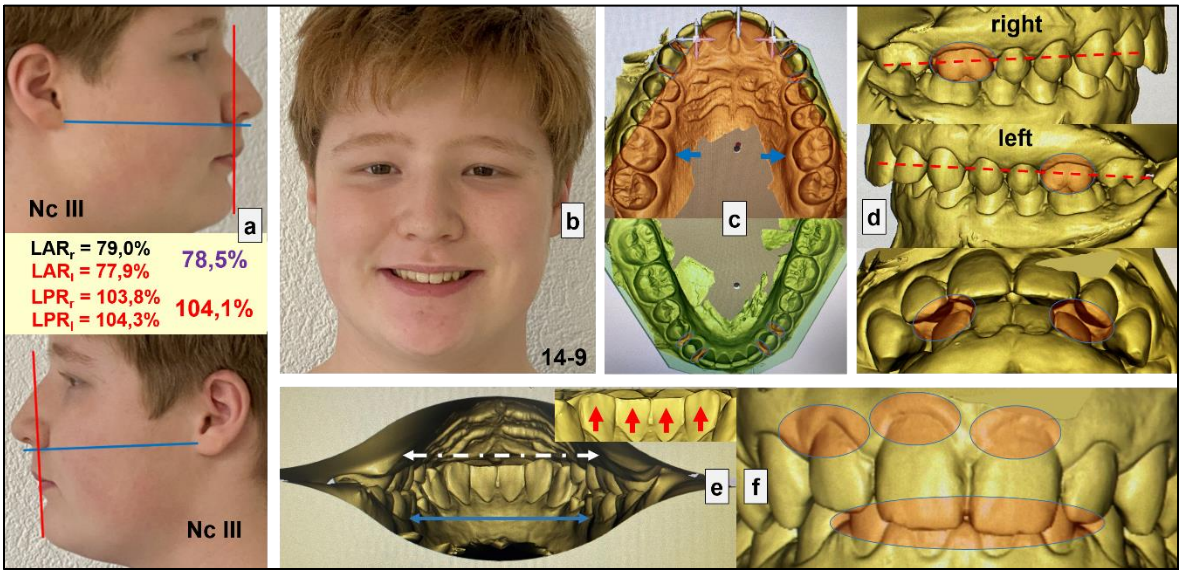
Figure 42l Closing the gap and slicing the contact points.



Source for Figure 42: Figure (**a**) from GÜRLER (2008) schematically shows the principal biomechanics of the arch-guided tooth movement during gap closure by the canine. Figure (**b**) from MÜLLER (2017) shows a possibility to compensate somewhat for the extraction of the upper second premolars in the lower anterior region by grinding the contact points and at the same time to gain some space in the lower anterior region (CHOUDHARY ET AL., 2015).

The son grinds his teeth at night. He has a frontal deep bite. At the same time, he has a LAR on the right, which fits large mandibles. The LAR on the left and his LPRs fit people with small mandibles, which can largely explain the gaps between the teeth mesially and distally of the lower canines (**Fig. 43**).

Figure 43| Dento-facial diagnostic for the son.

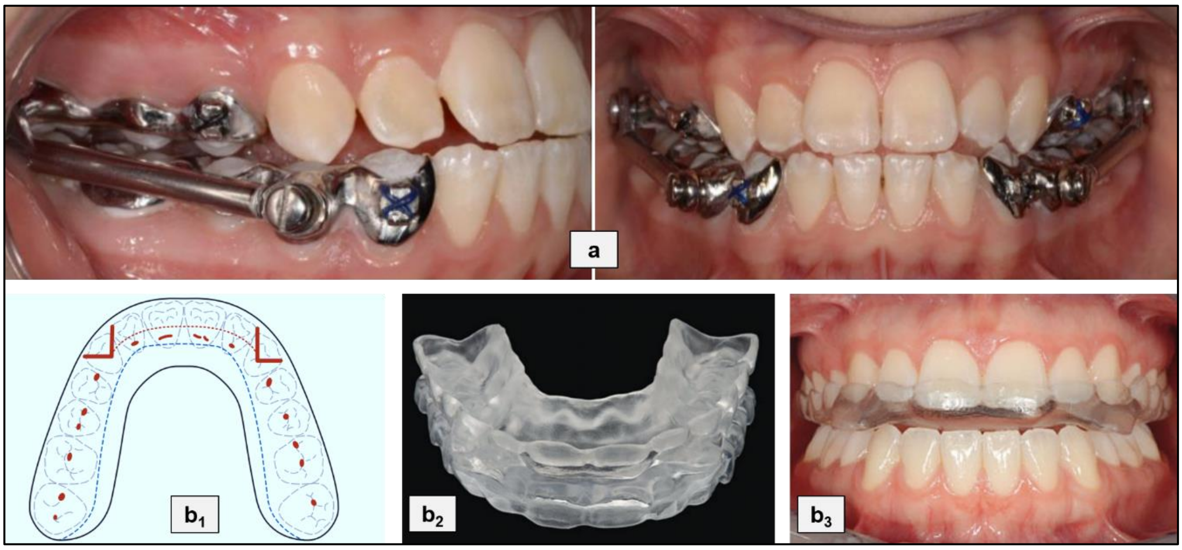


Source for figure 43: The own figure shows with figure (**a**) the son with a bilateral NK III. On the other hand, his LPRs as well as the left LAR fit persons with small lower jaws. Figure (**b**) shows the son's rather broad face type. Figure (**c**) shows his almost perfect alignments in permanent dentition with small gaps mesially and distally of the canines. Figure (**d**) shows an Angle class II on both sides, unsupported anterior teeth and a pronounced compensation curve. Figure (**e**) shows his flat palate and matching apical bases in the region of the first molars. The unnaturally abraded incisal edges of the lower incisors are special, confirming night bruxism. Figure (**f**) shows a symmetrical anterior situation with a deep bite and unusual gingival recessions.

A suggestion for therapy: The son is almost 15 years old and smaller than his twin sister, which according to KUCZMARSKI ET AL. (2002) (see Fig. 11) suggests that he is still before his growth spurt. The model analysis proves that he has been pushing the maxillary dentition strongly with his mandibular dentition for a long time without control, because the lower incisors show abrasions of the incisal margins, and the upper incisors are pressed against the bone in such a way that they could be the cause of the gingival recessions. Has this habit shifted the upper dental arch from an Angle class I to an Angle class II or would a class II also be present if it were not grinding? Both are possible and should be considered when planning treatment.

In the son's case, the calculated LOR_{right} = 91.6% and LOR_{left} = 91.6% are within the first standard deviation of MACHADO ET AL. (2019). This means that a transfer from an Angle class II to a natural Angle class I should be feasible if the dentitions are shifted against each other accordingly. In principle, the therapy option with a palatal implant (see Fig. 3) would offer itself here. With this therapy principle, the entire upper row of teeth is distalised, but the "gap problem" in the lower jaw is not solved at the same time. To the best of our knowledge, there is no actual "standard therapy" for this. However, there is the Herbst appliance - a functional orthodontic appliance worn 24 hours a day - which is recommended for Class II cases with ANB angles of less than 6° (RUF AND PANCHERZ, 2006). According to WICHELHAUS AND EICHENBERG (2013), the therapeutic success of an Herbst appliance is based on about 78% dental displacement. If teeth 17 and 27 are extracted in advance and the occlusion is straightened with straight-wire arches, the resistance of the maxillary dental arch is reduced and the distally directed force of the Herbst appliance acts more effectively on the upper dentition. A Michigan splint is recommended to secure the result in the upper jaw (**Fig. 44**).

<u>Figure 44l</u> The Herbst appliance and the Michigan splint.



Sources for Figure 44: Figure (**a**) from RÜHL (2018) shows the lateral and frontal view of an Herbst appliance brought into situ - also called Herbst hinge - with cast metal splints. Figures (**b_1**) to (**b_3**) from DEDEM AND TÜRP (2016) show three pieces of information on the Michigan splint. Figure (**b_1**) shows the distribution of antagonistic contacts on the splint surface after jaw closure and splint-guided forward and lateral thrust. Figure (**b_2**) shows a Michigan splint ready for delivery. Figure (**b_3**) shows an inserted Michigan splint with initial contacts, which is usually worn as protection against bruxism.

In this family, there is hardly any coincidence between the Norma classes and the Angle classes. However, the statement that the smaller the LPR, the more likely an Angle class II is present is true for the family spontaneously recorded here. However, this finding does not yet have general validity because it is "only" a case presentation. Nevertheless, studies with an appropriately blinded design should be conducted to test a corresponding hypothesis.

With regard to the LARs and the lower anterior tooth space balance, a plausible regularity is revealed, which is supported by the probabilisation of the TWSs discovered: Small mandibles with large LARs are more likely to have an anterior tooth space in the mandible and large mandibles with small LARs are more likely to have tooth spaces there.

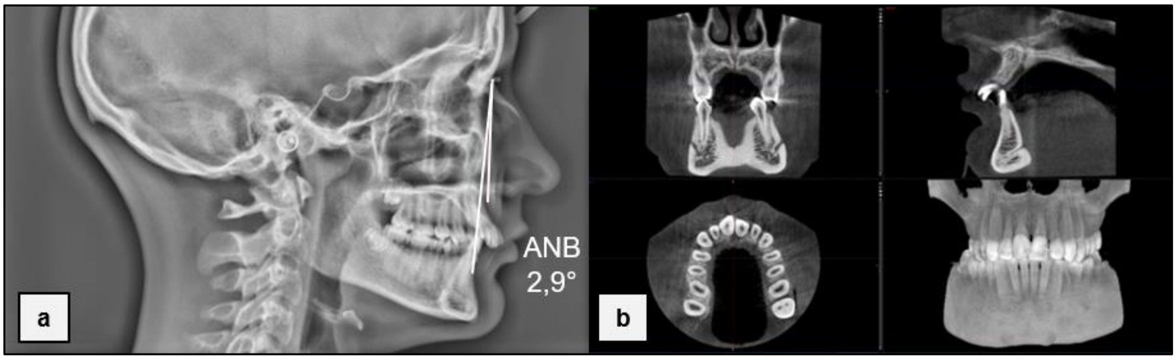
It is possible that the Norma classes can be used in heredity: If, for example, the frontal facial images are considered in Figure 34, then it can be said that M, D_2 and S or F, D_1 and D_3 are similar. The same assignment also largely applies to the Norma classes.

The members of the spontaneously recorded extended family presented here prove that only with the Primescan™ (SIRONA, D), with photography of the side profiles and with the presentation programme (PowerPoint®, Microsoft, USA) can a meaningful dento-facial diagnostic be made, even without a cephalometric X-ray analysis, which leads to a reasonable therapy proposal.

A dento-facial diagnosis with the Norma classification has the advantage that from permanent dentition on, the age-related head size change does not seem to play a role. However, in the cephalometric X-ray analyses of angular features, age-related head size change does play a role. For example, head growth reduces the ANB angle by an average of 0.1 degrees/year between the ages of 8 and 18 in untreated patients (BROABENT ET AL., 1975) or, according to more recent studies, by 0.2 degrees/year (GILBERT-BRESLER, 1993; BHATIA and LEIGHTON, 2001), and functional orthodontics reduces it by a median of 0.4 degrees/year, or even by 0.8 degrees/year depending on the age grouping (BODE, 2002). In addition, the Norma classification can take laterality into account and the two-dimensional cephalometric X-ray analysis cannot. Therefore, coupling a cephalometric X-ray with a model analysis is not particularly reliable.

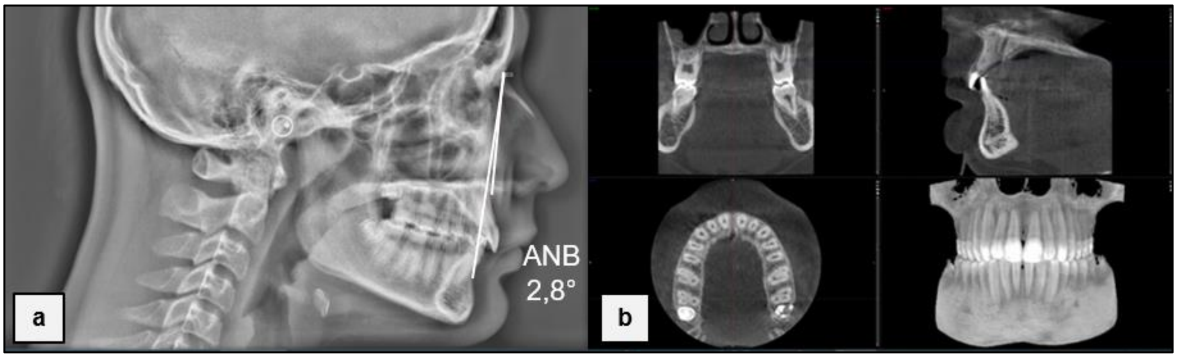
Nevertheless, it is recommended here that after the patient has agreed to an initial therapy proposal, findings documents on the skeleto-alveolar structures should also be prepared. This is because a cephalometric X-ray is needed to clarify possible insurance benefits and/or to record the initial skeletal situation - Usus - and because the radicular and periradicular conditions in the alveolar bone should be documented and assessed with a DVT image before starting therapy (PITTAYAPAT, 2015; JÄGER, 2015; DETTERBECK, 2017) (**Figs. 45 and 46**).

Figure 45| An initial cephalometric X-ray and an initial DVT image from the first daughter.



Source for Figure 45: The own illustration (**a**) of the cephalometric X-ray of the first daughter shows, for example, an ANB angle of 2.9° for objectifying the pre-therapeutic facial convexity. The own illustration (**b**) of the DVT image (volume 8 x 8 cm) of the first daughter with the image centred on the region of the first premolars shows that teeth 24 to 34 are in a non-occlusion there, that the palatal suture has not yet grown together, that the upper incisors are strongly proclined and that the mandibular incisors touch the upper mucosa because of the prominent deep bite.

Figure 46| An initial cephalometric X-ray and an initial DVT image from the son.



Source for Figure 46: The own illustration (**a**) of the cephalometric X-ray of the son shows, for example, an ANB angle of 2.8° for objectifying the pre-therapeutic facial convexity. The own figure (**b**) of the DVT image (volume 8 x 8 cm) of the son shows with the image centring on the region of the extraction teeth 17/27 that the maxillary sinus is not interposed between the roots and that the teeth 18/28 are arranged regular. They will replace teeth 17 and 27 that are planned for extraction. Teeth 41 and 31 just touch the palatal mucosa.

Dentists and orthodontists should respect the desire and will of their patients, as well as their health, in addition to following evidence-based studies on feasible treatment limits. Therefore, patients should first agree to a primary clinically evaluated therapy suggestion before further clarification with X-rays is made.

Every X-ray means radiation exposure, even if this is relatively small in the discipline of orthodontics (VOIGT, 2018). A clinically determined treatment plan can still be changed based on the skeletal findings from the cephalometric X-ray and/or the alveolar findings from the DVT image with the appropriate justification.

Nature promotes the way of gene mixing by bringing together the most diverse partners, which leads to an enormous variety of cephalometric differences. Therefore, it seems to be rather a lucky coincidence when a patient has a natural excellent normocclusion according to ANGLE (1899).

The results found here fit the conclusions of NORMANDO ET AL. (2013), who consider that dental space deficiency is not so much the result of dietary habits, but rather the result of heredity. The assumption is added here that the tooth widths of the teeth in the mandible could be genetically determined independently of their skeletal base and/or their lateral affiliation in such a way that they can be derived from different parents or even from the grandparents (see theoretical thought experiment, chapter 1.3.2) and, if the geometric shape of the skeletal bases is suitable, no frontal crowding, or tooth gaps will develop.

General information on the Angle classification: As long as there are no studies proving that orthodontic therapies which do not result in an Angle Class I in the molar region lead to temporomandibular joint problems or other immediate or chronic inflammatory reactions, the perfect Angle Class I of the first molars does not necessarily have to be targeted as a result. However, my own 24 years of practical experience have shown that a properly adjusted canine relation usually represents a reliable and stable anterior result.

6 CONCLUSIONS

The following eleven conclusions result from the discussion made:

1. The validity of the manual tooth width measurement on the screen is significantly higher than the automatic option offered by the $SW_{2.0}$® software.

2. Due to its laterality, the Norma classification has a discrimination potential that is superior to that of cephalometric images in terms of 3D diagnostics.

3. The TWs of the first premolars differ significantly less than all other antagonists, which is why they could be useful as a dental classification.

4. Five of the six Norma class subgroups have a TWs characteristic of homologous antagonists or neighbouring teeth, which gives the practitioner advantages in diagnostic differentiation to mandibular size.

5. The discovery that the lateral anterior TWSs in the Norma classes vary significantly more in the mandible than in the maxilla indicated that other cephalometric features might also differ in the Norma classes.

6. Female patients have significantly smaller LTWSs than male patients, but they do not differ significantly in their LARs and LORs from the male patients.

7. The lateral mandibular TWSs of patients with small mandibles are significantly smaller than those of patients with medium-sized mandibles, while at the same time their upper lateral TWSs do not differ significantly.

8. In white patients with malocclusion, the LARs and the LPRs should always be calculated in the Norma class pre-therapeutically, because they may be the cause of the malocclusion.

9. In white patients with malocclusion, LORs should always be calculated pre-therapeutically for comparison with the OR_{μ} of MACHADO ET AL. (2020).

10. Bolton had multiple selection bias in his analysis, which is why his norm values for AR and OR should be used for retrospective assessment of one's own therapy results rather than as a diagnostic reference.

11. In white patients with malocclusion, the first standard values for TWSRs with different mandibular sizes were revealed, which can plausibly explain the crowding of the mandibular anterior teeth, among other things.

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8 ABSTRACT

INTRODUCTION: A critical appraisal of BOLTON's study reveals six factors of uncertainty in the derivation of his norm values for the Anterior and Overall Ratio.

AIM: The main aim of this study was to verify BOLTON's normal values with respect to laterality, sex and three mandibular sizes.

METHOD: The dental plaster models of 91 white patients with malocclusion from four randomly selected dental practices were evaluated. On the basis of two lateral facial photographs of these patients, each of the two sides of the face was assigned a relative mandible size – three Norma classes [Nc III = large, Nc I = medium, Nc II = small] –. This resulted in 182 data sets of tooth widths [TW], lateral tooth sums [TWS] and lateral anterior as well as overall TWS ratios [TWSR: LAR and LOR]. These were examined for differences in gender and Norma classes (six subgroups) and in relation to Bolton's norm values - Anterior Ratio [AR]; Overall Ratio [OR]. The study was completely blinded and the testing for significant differences ($p \leq 0.05$) was performed using SPSS Statistics 23® (IBM, USA).

RESULT: Five of the six subgroups examined showed a typical TW ratio of homologous antagonists or neighbouring teeth. The lateral anterior TWS varies significantly and the lateral overall TWS tends to variate significantly more in the mandible than in the maxilla. Female patients have significantly smaller lateral TWS than male patients, but they do not differ significantly in their lateral TWSR - LAR and LOR -. The LAR and LOR in male patients with medium and/or large mandibles differ significantly from Bolton's AR and OR.

DISCUSSION: The Norma classification has a surprisingly high potential of discrimination. It may reveal dentofacial coincidence and possibly other cephalometric differences. In 1958 BOLTON very probably had relatively few male patients with midsize and large mandibles in his patient pool and his premise that the lower TWS are more variable than the TWS in the maxilla has been confirmed for the first time.

CONCLUSION: The norm values for the LARs and the LORs in the Norma classes are diagnostically superior to BOLTON's norm values for the AR and OR.

9 APENDIX

9.1 List of tables

9.2 List of figures

9.3 List of abbreviations

Abbreviation	Description
TW	Tooth width (TWs = tooth widths) = mesio-distal tooth width.
TWS	Tooth width sum (TWSs = tooth width sums).
TWSR	Intermaxillary tooth width sum ratio.
Ceph	Cephalometric X-ray.
DVT	Digital Volume Tomographie.
Q	Adult Quotient = The factor by which men grow taller than women.
Sna	Spina nasalis anterior = most anterior point in the midline of the apertura piriformis.
Nc	Norma class.
Ap	Alara posterior = Most posterior point of the nostril.
Gl	Glabella = foremost point of the forehead between the eyebrows.
Snp	Spina nasalis posterior = most posterior point of the palatine bone.
Ac	Alara caudale = lowest point of the nostril.
aE	anterior Earlobe point = most anterior point of the base of the earlobe.
Pg‘	Soft tissue Pogonion = anterior point of the chin (horizontal head posture).
D	Discriminant = Constructed vector of aE tangent to Ac.
E	Eye point = Most anterior point of the eyelid fold.
AR	AR = Anterior Ratio: BOLTON's intermaxillary anterior arch ratio.
OR	OR = Overall Ratio: BOLTON's total intermaxillary arch ratio.
LTWS	Laterale Tooth width sums: LATS, LOTS, LPTS.
$LATS_{(max)}$	Lateral TWS of the three permanent anterior teeth of one side in the maxilla.
$LOTS_{(max)}$	Lateral TWS of the first six permanent teeth of one side in the maxilla.
$LPTS_{(max)}$	Lateral TWS of the three permanent posterior teeth of one side in the maxilla.
$LATS_{(man)}$	Lateral TWS of the three permanent anterior teeth of one side in the mandible.
$LOTS_{(man)}$	Lateral TWS of the first six permanent teeth of one side in the mandible.
$LPTS_{(man)}$	Lateral TWS of the three permanent posterior teeth of one side in the mandible.
LTWSR	Lateral tooth width sum ratio (= LBR: Laterale Bolton Ratio).
LBR	Laterale Bolton Ratios: LAR, LOR, LPR; in %.
LAR	Laterale Anterior Ratio = $100 \cdot LATS_{(man)} / LATS_{(max)}$.
LOR	Laterale Overall Ratio = $100 \cdot LOTS_{(man)} / LOTS_{(max)}$.
LPR	Laterale Posterior Ratio = $100 \cdot LPTS_{(man)} / LPTS_{(max)}$.
IK	Maximum intercuspidation.
O	Orthogonal = Constructed perpendicular vector to the discriminant D.
α	Eye angle
β	Ear angle.
γ	Maxillary angle.
δ	Mandibular angle.
WHO	World Health Organisation.
N	Nasion = The most anterior point of the nasofrontal sutura.
Go	Gonion = anatomical vertex in the angle of the mandible.
S	Sella turcica = An imaginary centrally located point in the hypophysial fossa.

9.4 Statement on the word of honour

"I, Martin vom Brocke, declare on my honour and with my own handwritten signature that I have written this dissertation on the subject: A review of BOLTON's norm values (1958) in white patients with malocclusions, taking into account lateral difference, mandibular size and gender, independently, without the aid of unauthorised aids and without the undisclosed help of third parties, and that I have not used any sources or aids other than those indicated. I confirm that I have complied with the guidelines for ensuring good scientific practice.

All passages that are based literally or in spirit on publications or lectures by other authors are marked as such with the correct citation (see "Uniform Requirements for Manuscripts (URM)", www.icmje.org). The corresponding chapters on methodology (especially practical work, laboratory determinations, statistical processing) and results (especially figures, graphs and tables) comply with the URM and are my responsibility.

Krems, February 2021

Signature: 

DANUBE PRIVATE UNIVERSITY
Fakultät Medizin/Zahnmedizin

BESCHEINIGUNG EXAMEN RIGOROSUM

TITEL, VOR- UND FAMILIENNAME, NACHGESTELLTER TITEL
Dr. med. dent. Martin vom Brocke MSc
GEBURTSDATUM
25.07.1969

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STUDIENGANG
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GESAMTNOTE
summa cum laude

Krems, 24.09.2021

Thema der Dissertation	Benotung Gutachter 1	Benotung Gutachter 2
Kritische Bewertung der Normalwerte von W. Bolton bei weißen Patienten mit Zahnfehlstellungen unter Berücksichtigung von Seitenunterschied, Unterkiefergröße und Geschlecht	summa cum laude	summa cum laude

Examen Rigorosum	Note
	summa cum laude

MIT DEM EXAMEN RIGOROSUM ERWORBENER AKADEMISCHER GRAD:

Doctor of Philosophy (PhD)

DPU
DANUBE PRIVATE UNIVERSITY
Fakultät Medizin/Zahnmedizin

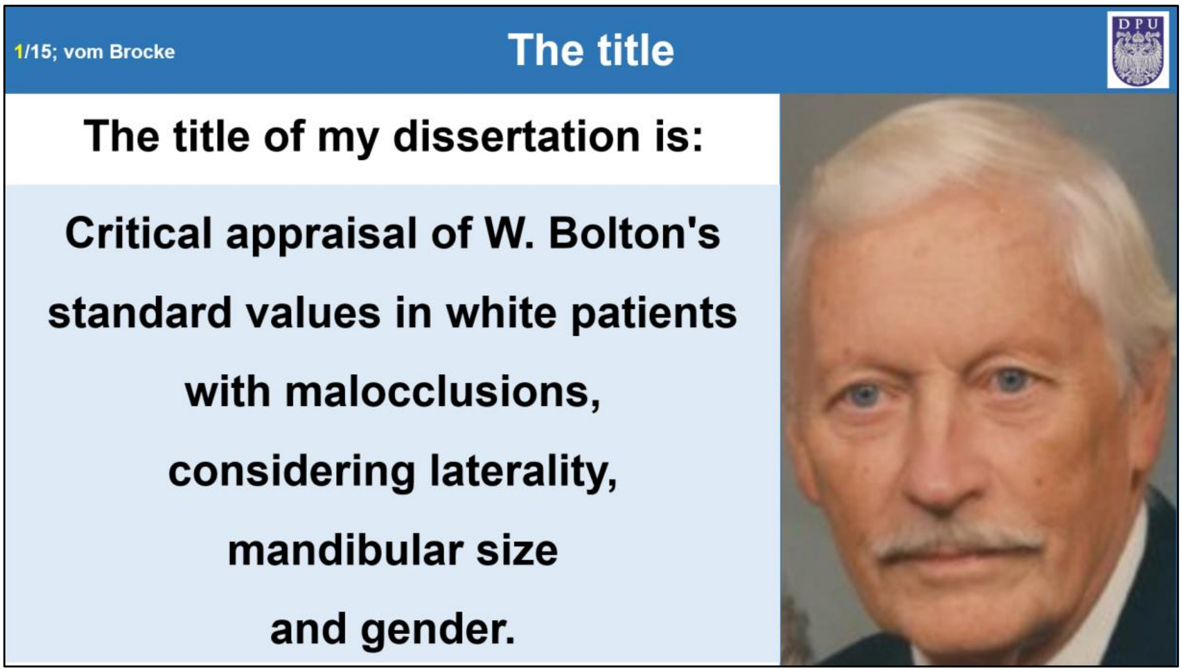
Prof. h.c. Marga B. Wagner-Pischel
Präsidentin

Prof. Dr. Dr. Rüdiger Junker MSc
Wissenschaftlicher Leiter

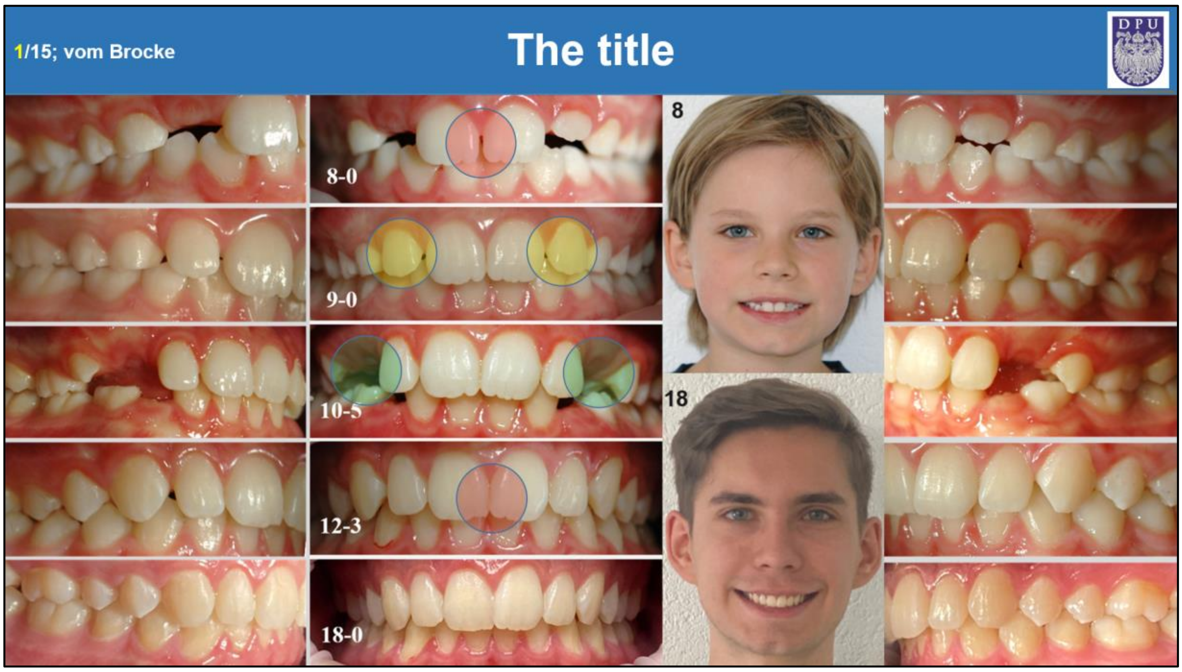
Gesamtnote: summa cum laude (ausgezeichnet), magna cum laude (sehr gut), cum laude (gut), rite (genügend)
Noten: summa cum laude (ausgezeichnet) = 0, magna cum laude (sehr gut) = 1, cum laude (gut) = 2, rite (genügend) = 3

Presentation for the Exam Rigorosum

Double slide 1

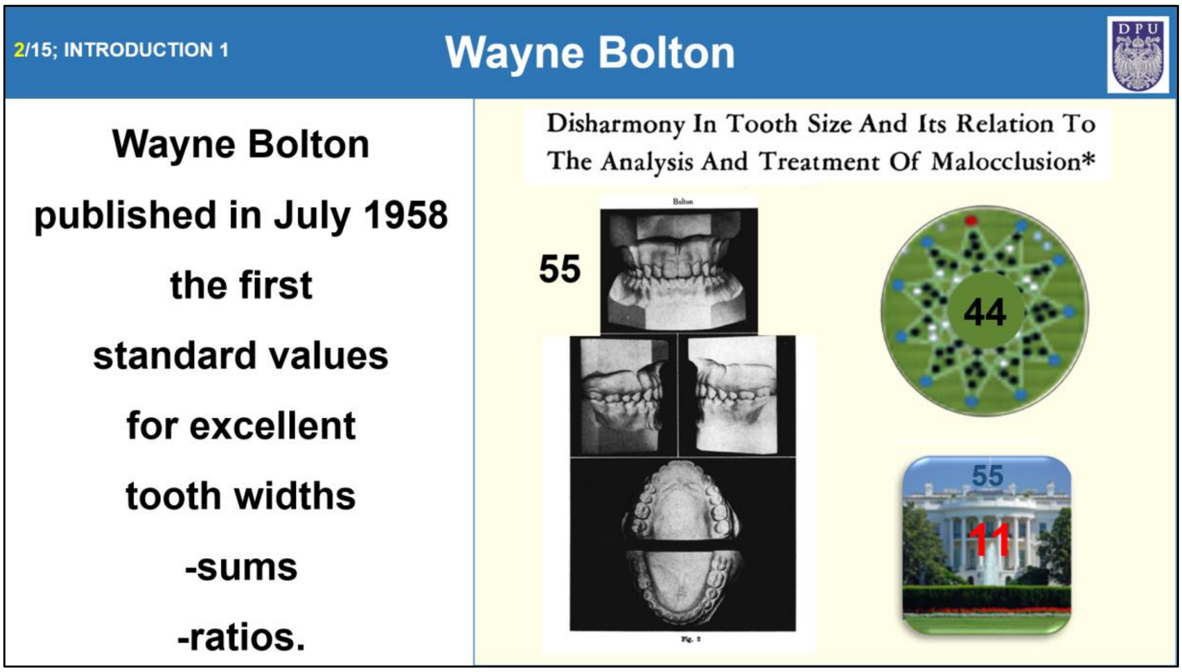


The title of my dissertation is: Critical appraisal of W. Bolton's standard values in white patients with malocclusions, considering laterality, mandibular size and gender. Wayne Bolton was an orthodontist who believed that disharmony of tooth sizes increases the amount of therapy required.

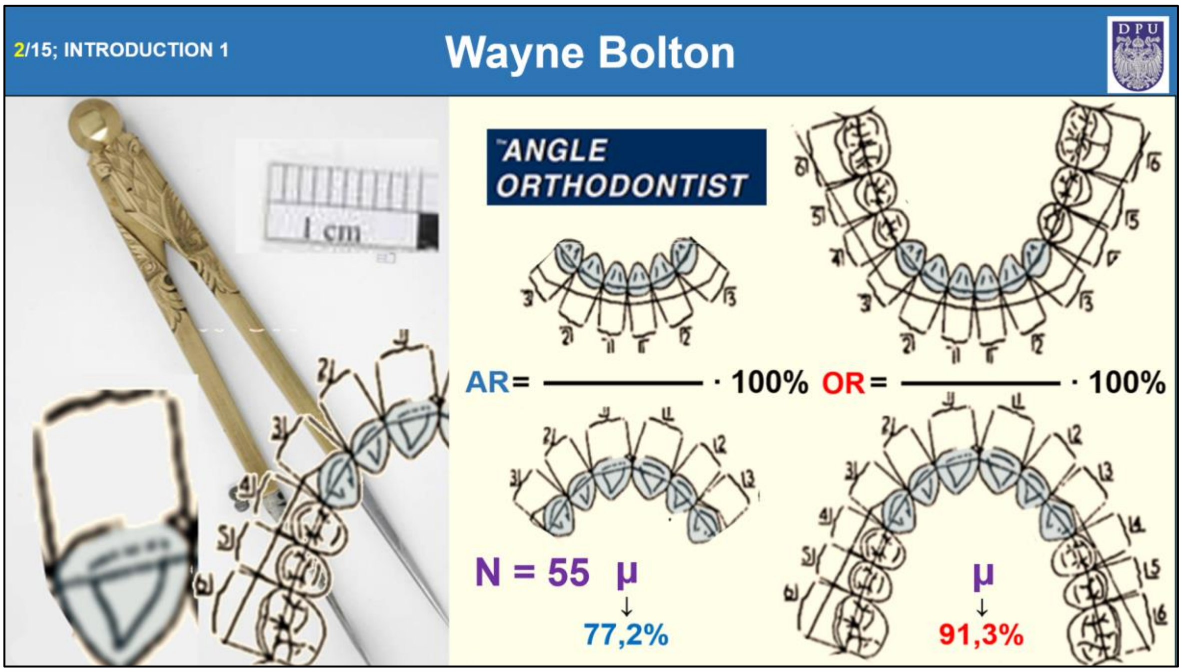


By disharmony of the tooth sizes, Wayne Bolton meant a reciprocally disturbed fitting accuracy of the permanent teeth, which must not be disturbed, because otherwise the tooth gaps, tooth misalignments, tooth dysfunctions or tooth misalignments caused by the loss of the milk teeth cannot disappear again by themselves.

Double slide 2

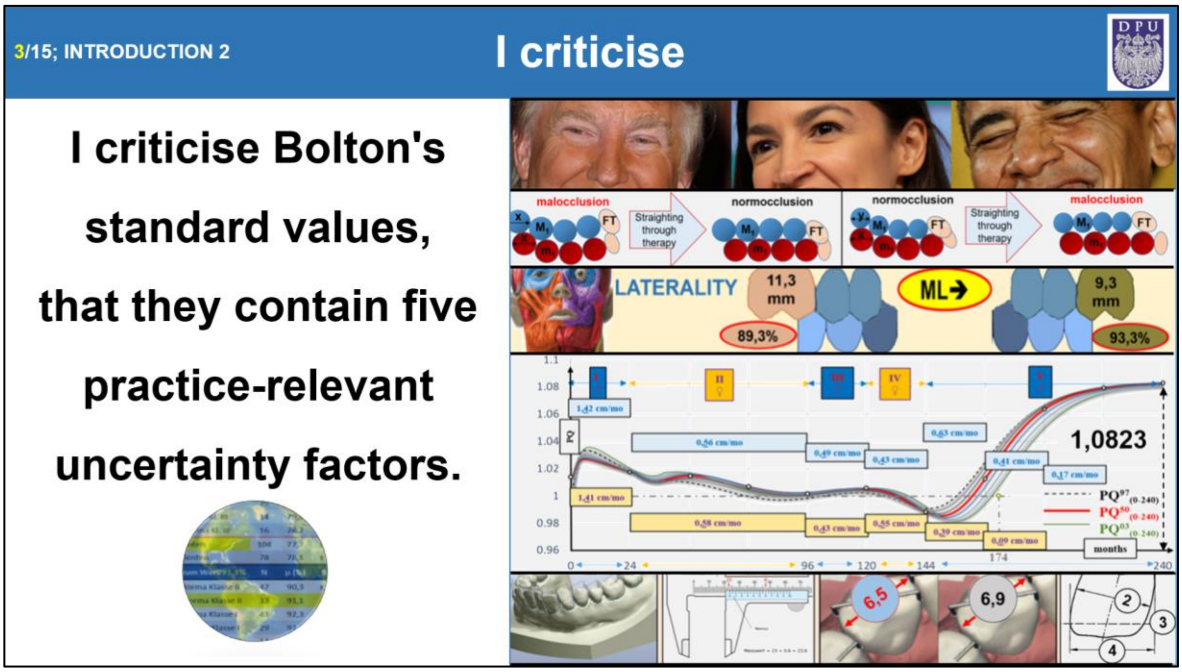


Wayne Bolton published the first standard values for excellent tooth width sum ratios in July 1958. He had derived these from 55 plaster models with matching dentitions. 44 of these plaster models corresponded to orthodontic status and all 55 models came from eleven different dental centres in the region of Washington.

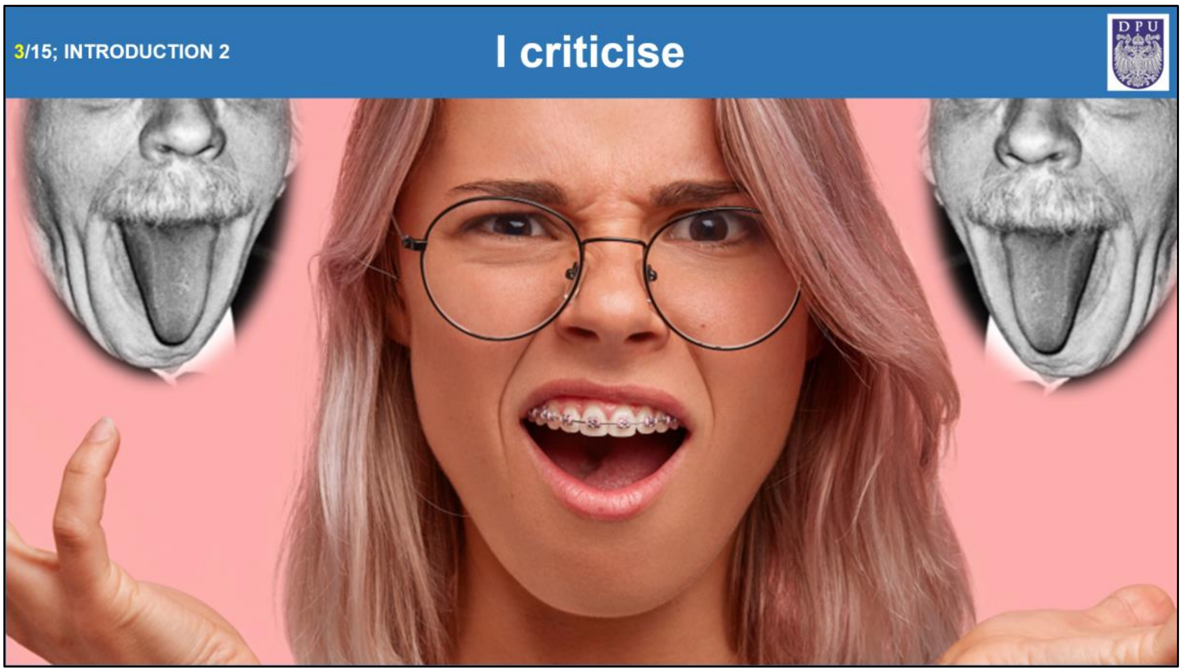


Wayne Bolton summed the tooth widths of the permanent anterior teeth to anterior arches and of the first twelve permanent teeth to total arches, then divided the lower arches by the upper arches to obtain ratio values in percent. The two mean values of the 55 calculated ratio values then corresponded to his standard values for the anterior and the total tooth area.

Double slide 3

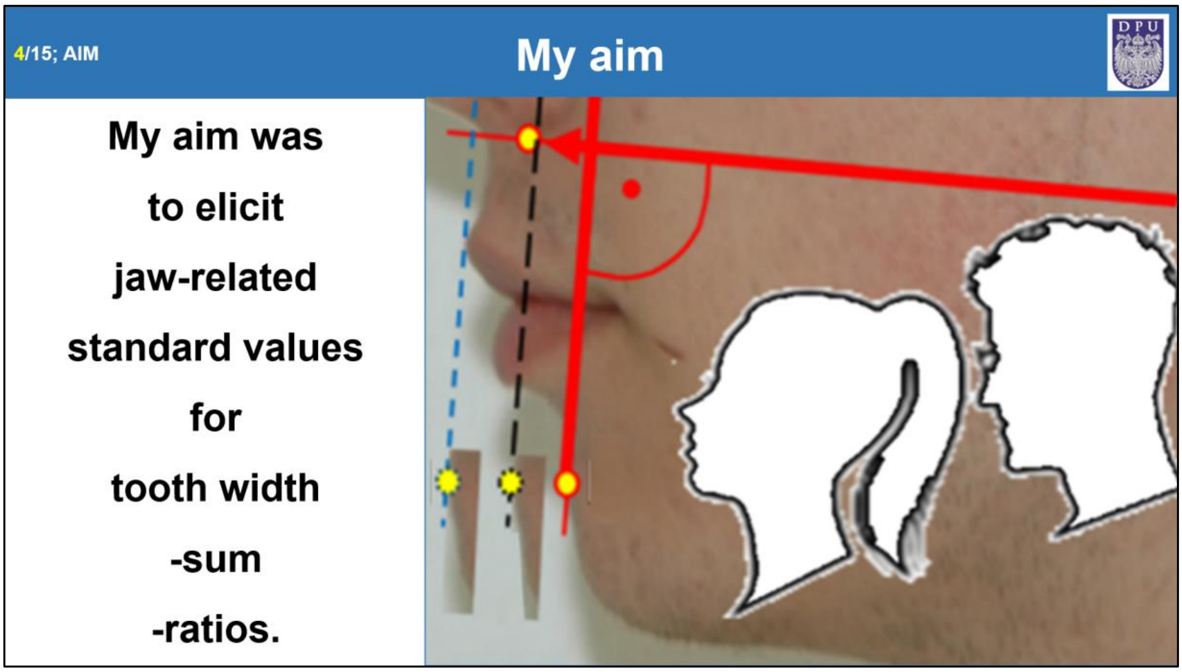


I criticise Bolton's norm values for containing five practice-relevant uncertainty factors. These are patient ethnicity, the Spee curve, side differences, gender distribution and measurement validity. In addition, last year a meta-analysis revealed that its standard values are significantly too small compared to the rest of the world, without at least having an explanation for this.

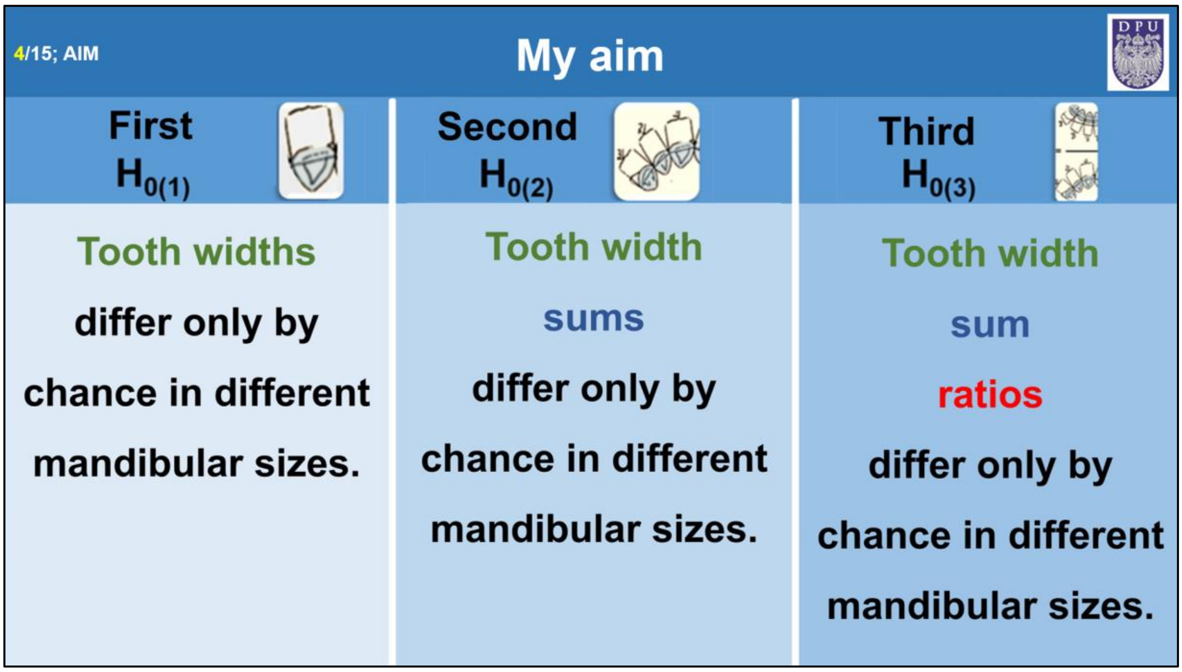


Although with the above-mentioned meta-analysis we now have global norm values for tooth size harmonies at our disposal, we still cannot say whether the upper jaw or the lower jaw is responsible for a tooth size disharmony. BUT THAT IS EXACTLY WHAT I NEED TO KNOW SO THAT I CAN PROPOSE AN UNDERSTANDABLE THERAPY.

Double slide 4

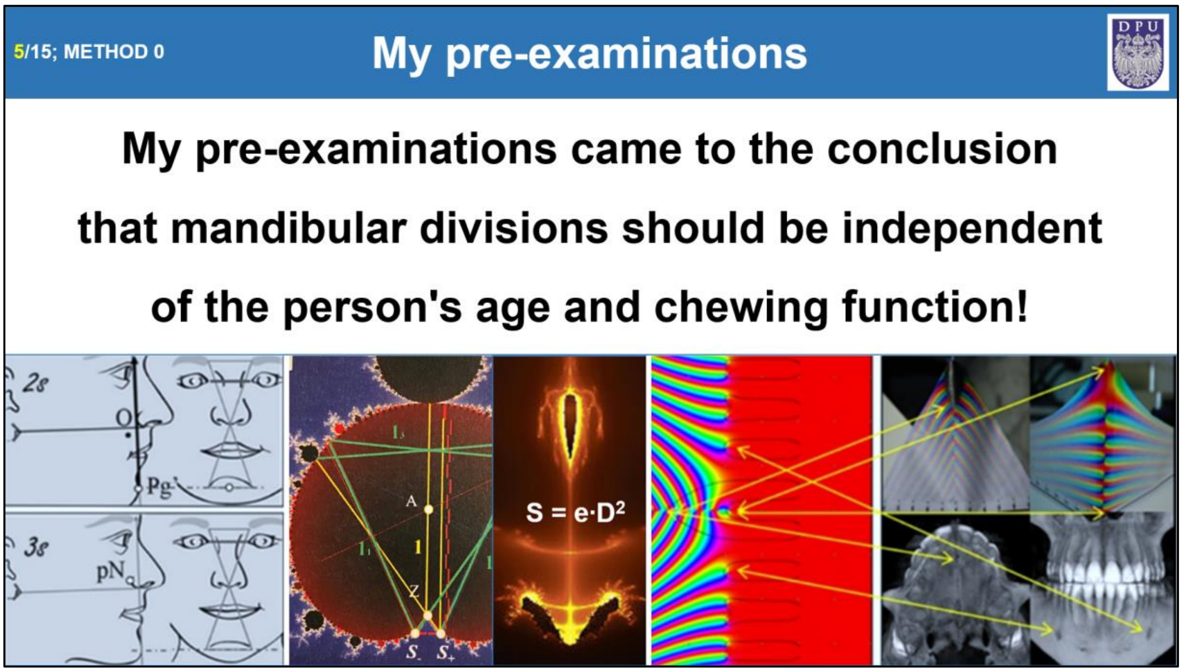


My aim was to elicit jaw-related standard values for tooth width sum ratios. This goal seemed unattainable for the maxilla because its outline is not visible. Therefore, I focussed my preliminary investigations on the lower jaw sizes of female and male patients.

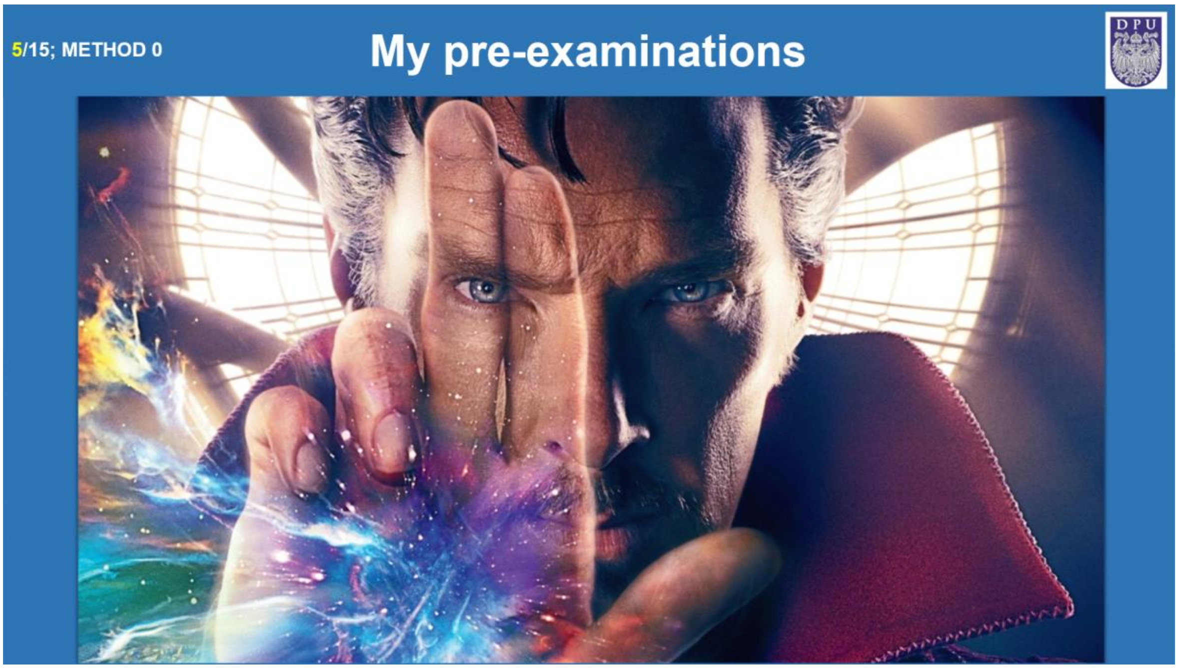


Current doctrine assumes that the tooth width sum ratios in female and male patients differ only by chance in various mandibular sizes.

Double slide 5

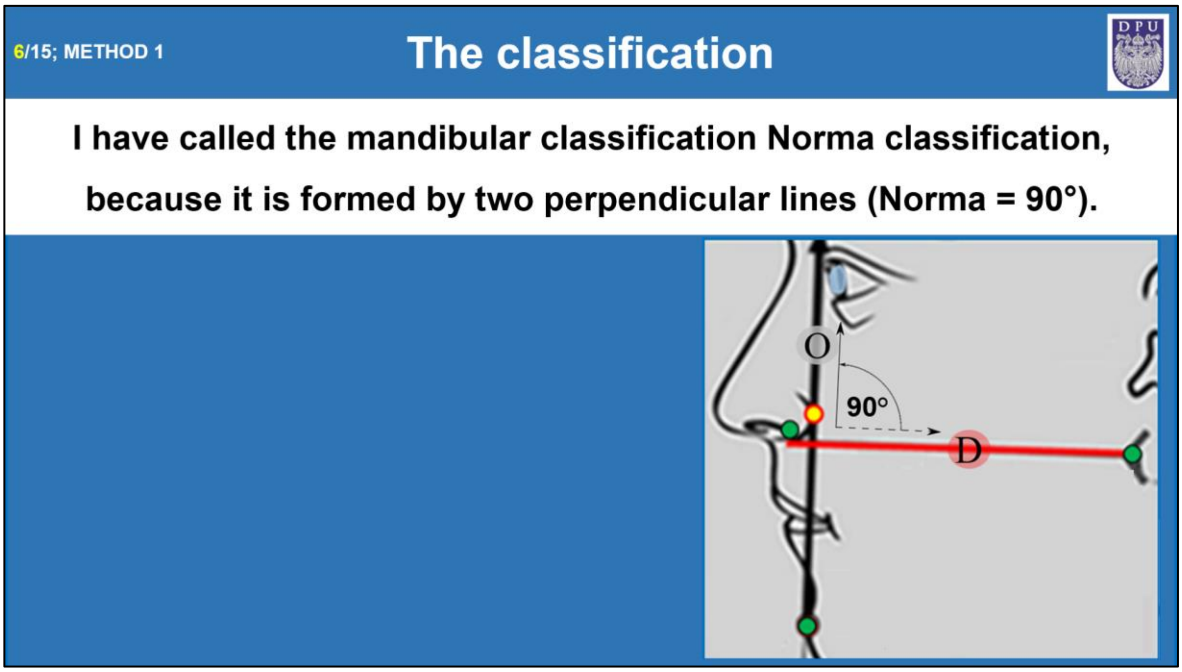


My pre-examinations concluded that mandibular divisions should be independent of person age and masticatory function! This conclusion germinated from the combination of spatial geometry, self-similarity dimensions and complex arithmetic that can be used to create mystical thought models. The most impressive of these thought models led me to the deep understanding that there is a reliable three-part mandibular classification that can reveal the coincidence between tooth widths and mandibular sizes.

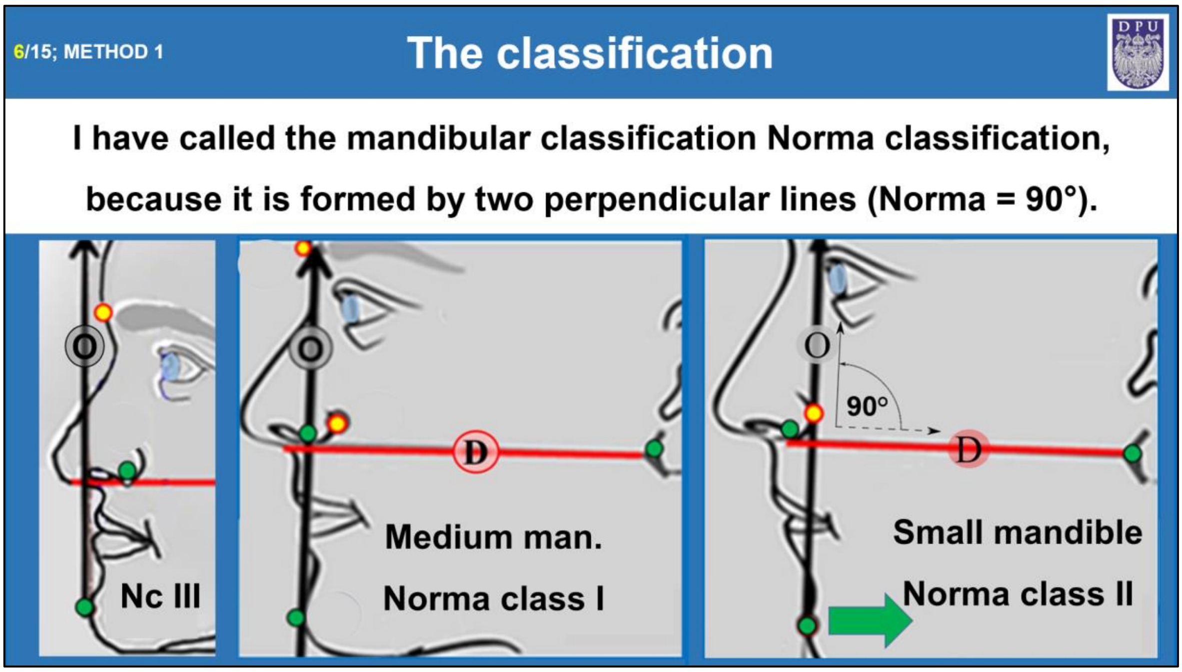


I chose the tripartite out of respect for the founder of orthodontic science - Edward Angle, who recommended the tripartite in 1899.

Double slide 6

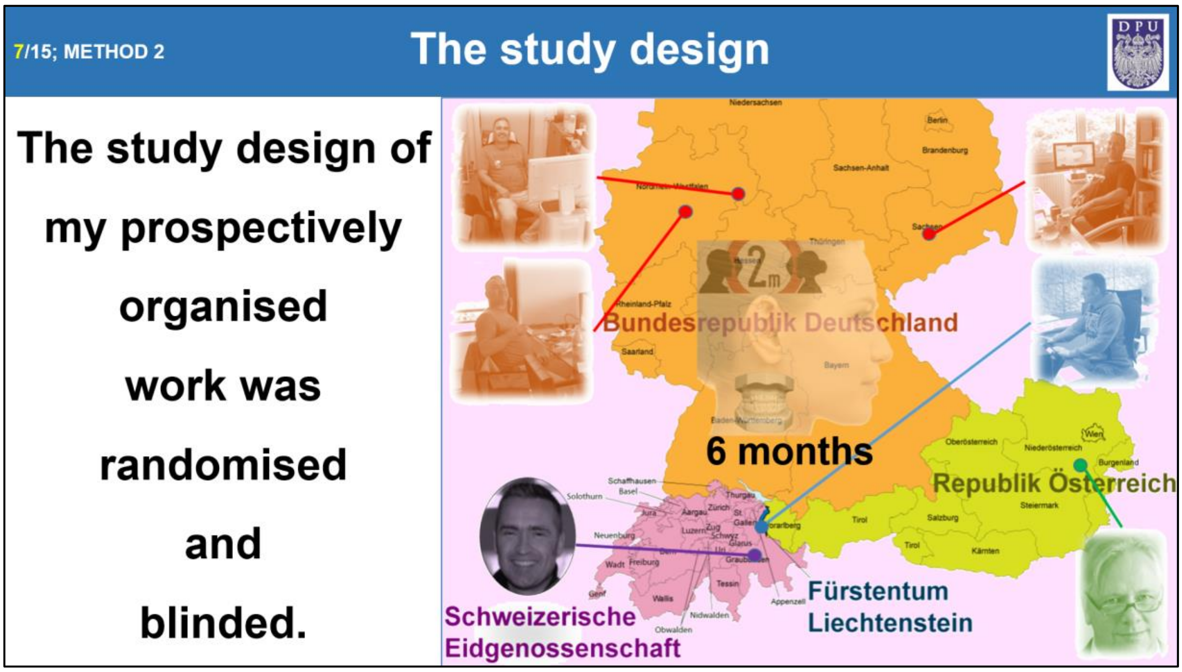


I have called the mandibular classification Norma classification because it is formed by two perpendicular straight lines (Norma = 90°). If a straight-line D is drawn tangentially to the lowest nostril point from the most anterior attachment point of the earlobe, then a projective discrimination plane D is created, which represents the morphological base of the upper jaw. If an orthogonal line O is then drawn perpendicular to D from the anterior chin point, then three mandibular sizes can be differentiated with O in relation to the anterior nasal space.

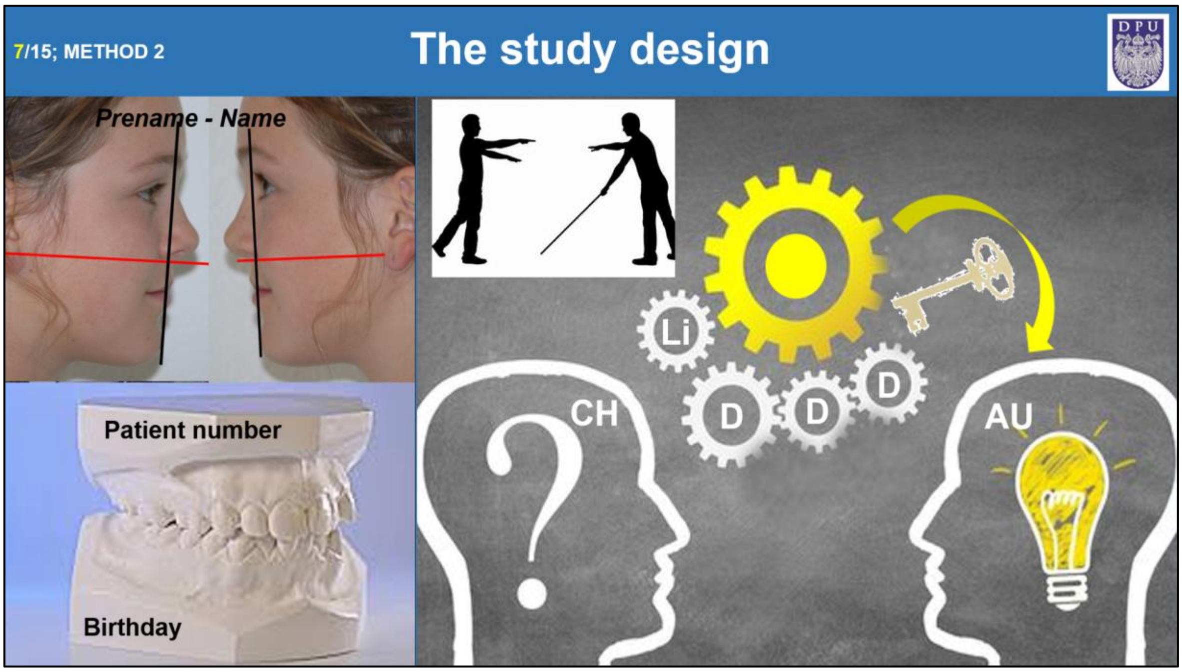


If O passes over or behind the most distal point of the nostril, then this person has a small mandible.
If O passes in the area of the anterior nasal cavity, then this person has a medium mandible.
If O passes in front of the most anterior point of the forehead, then this person has a large mandible.

Double slide 7

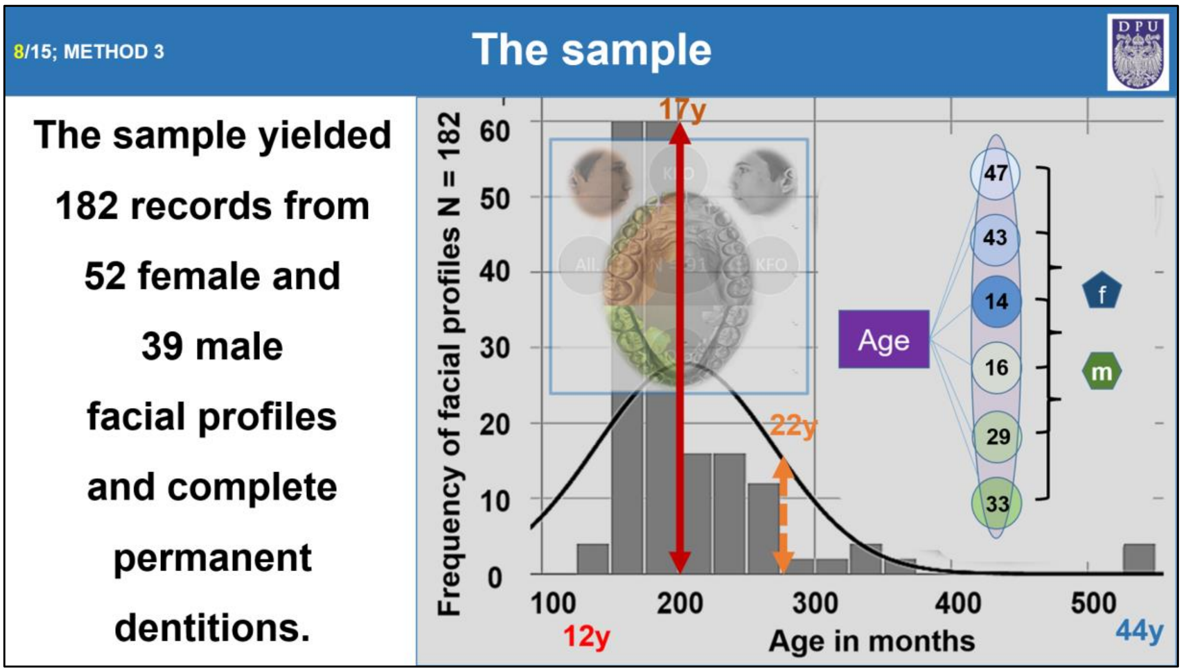


The study design of my prospectively organised work was randomised and blinded. During 6 months, three dental practices from Germany and one dental practice from Liechtenstein collected profile pictures of white patients and plaster models of their malocclusions for me. I then visited the four colleagues with my iPhone™ and Primescan™ to photograph the profile pictures and scan the plaster models.

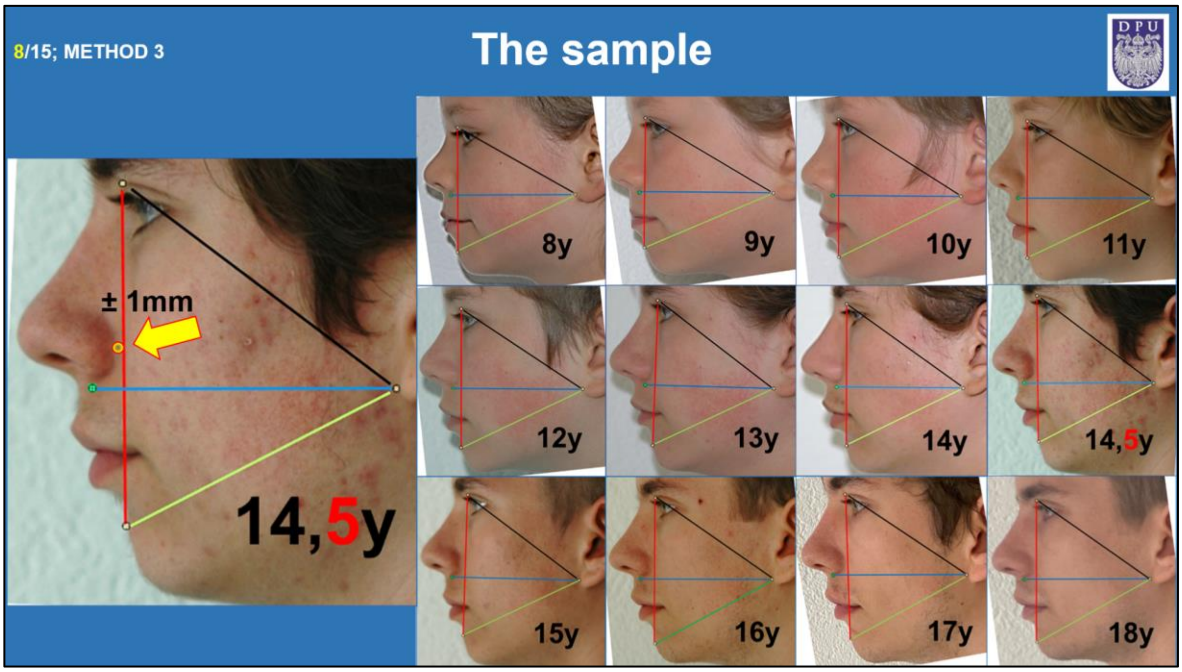


The profile pictures were only labelled with the first name and the name, and the plaster models were only labelled with the patient number and the date of birth so that I could not recognise the allocation key, which the colleagues only forwarded to the statistician in Vienna for the analysis of the recorded sample.

Double slide 8

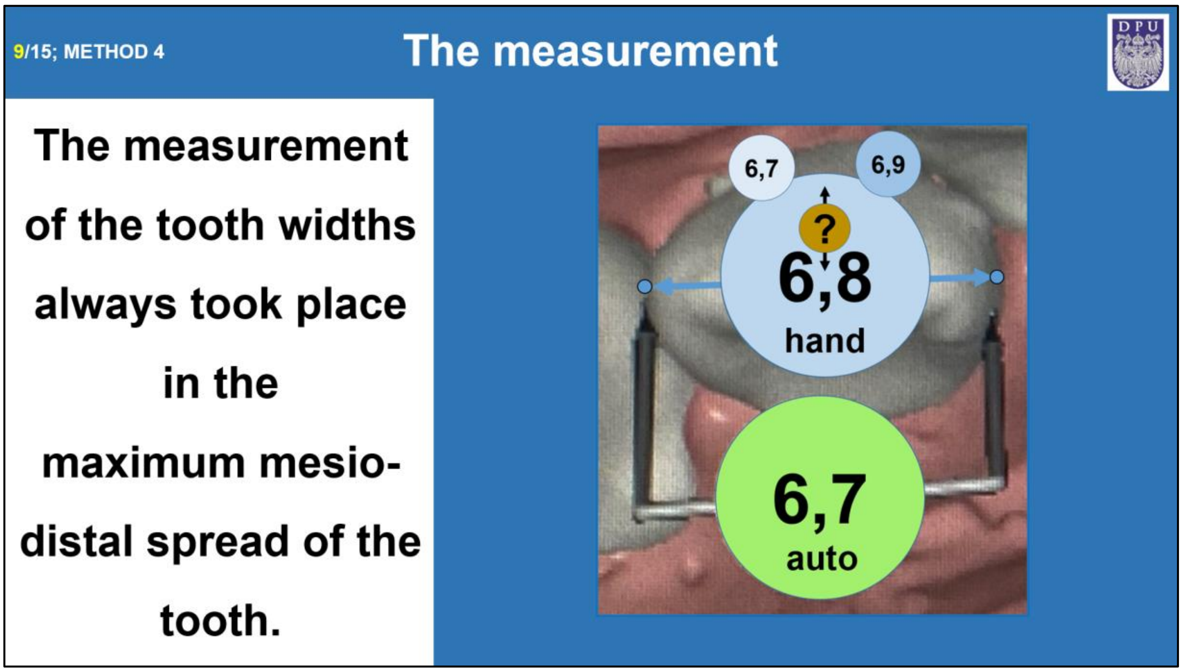


The sample yielded 182 data sets of 52 female and 39 male facial profiles and complete permanent dentitions. The age of the proband ranged from 12 to 44 years and was largely evenly distributed among the six subgroups, and there was no significant contingency in terms of gender in any of the six subgroups. The median value of the age distribution was 17 years, and the mean value was 22 years.

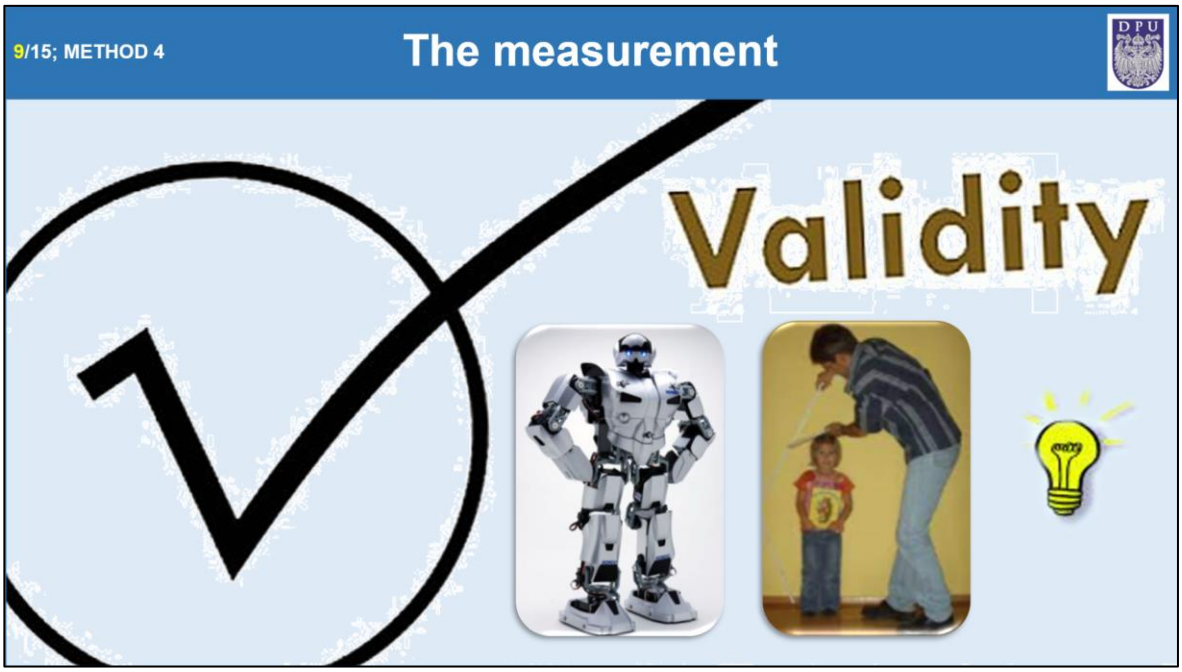


It is not particularly surprising that the age was not normally distributed because most patients are interested in orthodontic treatment between the ages of 8 and 18. I have added this series of pictures to show that even the pubertal growth spurt has practically no influence on the allocation to the Norma classes.

Double slide 9

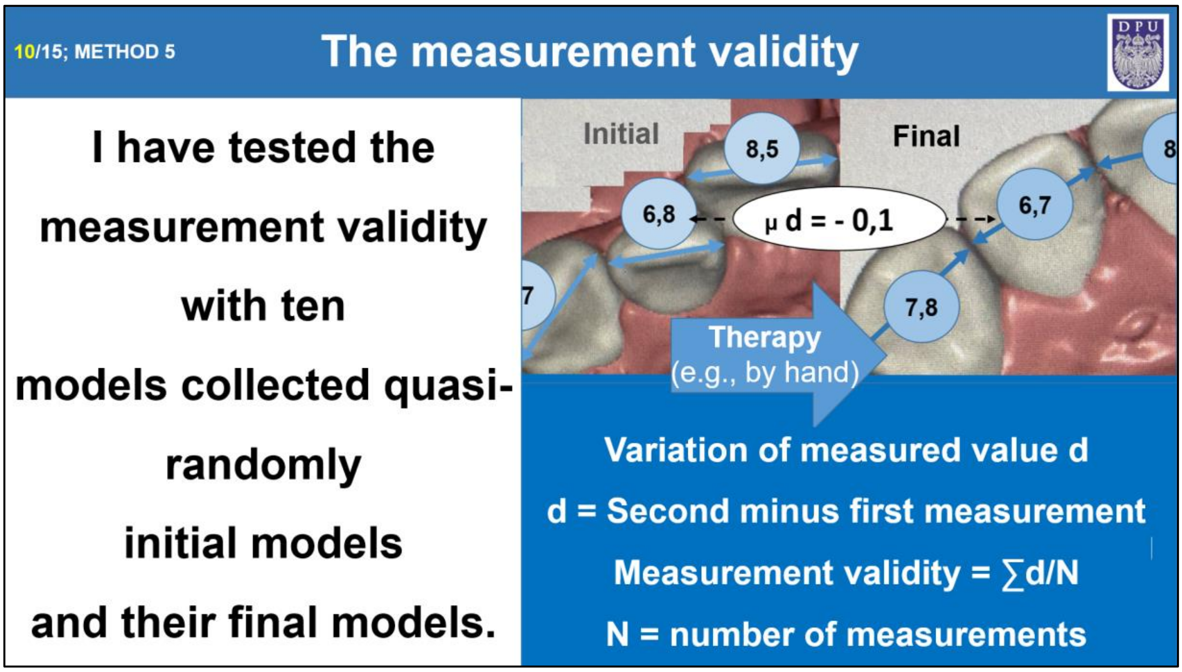


The tooth width was always measured in the maximum mesio-distal spread of the tooth. *It was carried out once manually by me and once automatically by the software of the scanner. I noticed that my manual measurement was subject to a certain fluctuation in the measured value, which I could not observe in the automatic measurement*.

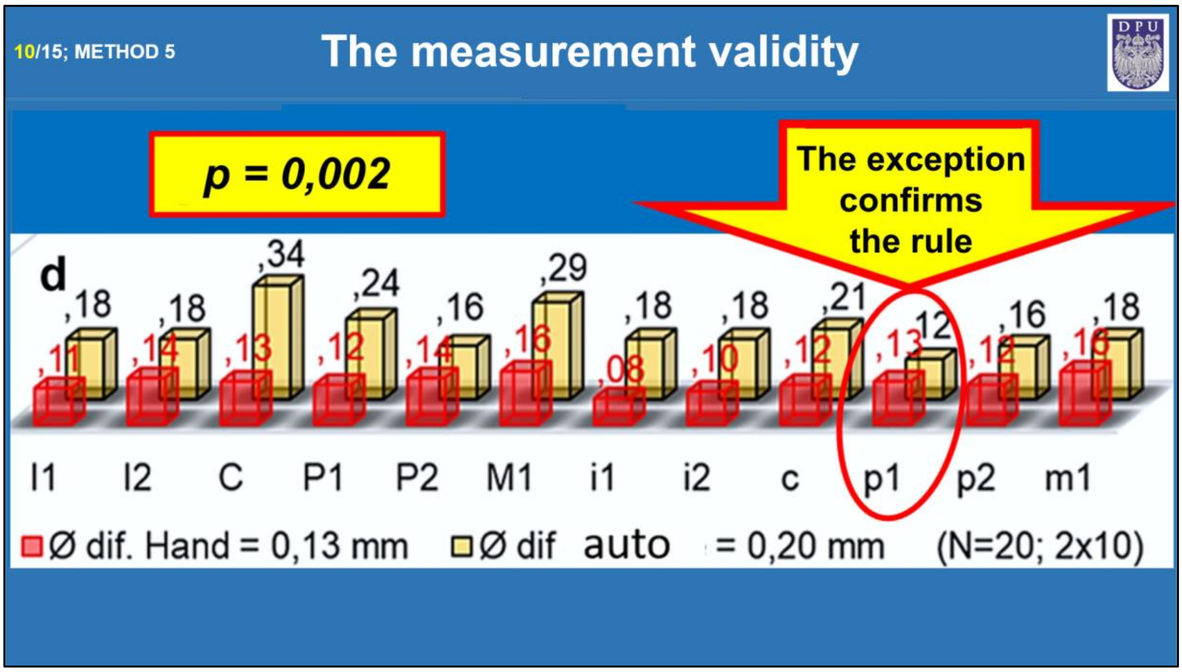


Since it is indeed possible that the automatic measurement does not show any fluctuation in the measured value, I first had to compare the validity of the two measurement methods.

Double slide 10

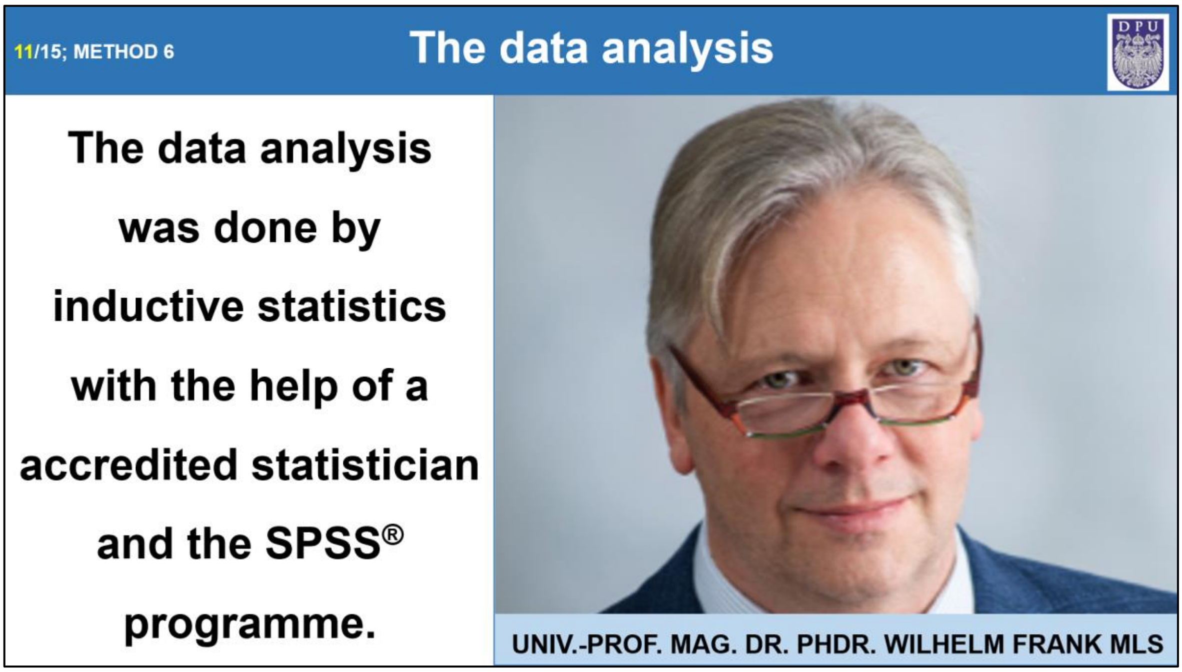


I have tested the measurement validity with ten quasi-randomly recorded initial models and their final models. For example, the mean variation in measurement (N = 10) for the upper lateral incisors was 100 micrometres. In principle, the measurement validity of a measurement method corresponds to the mean value, which is calculated from all its measurement value fluctuations.

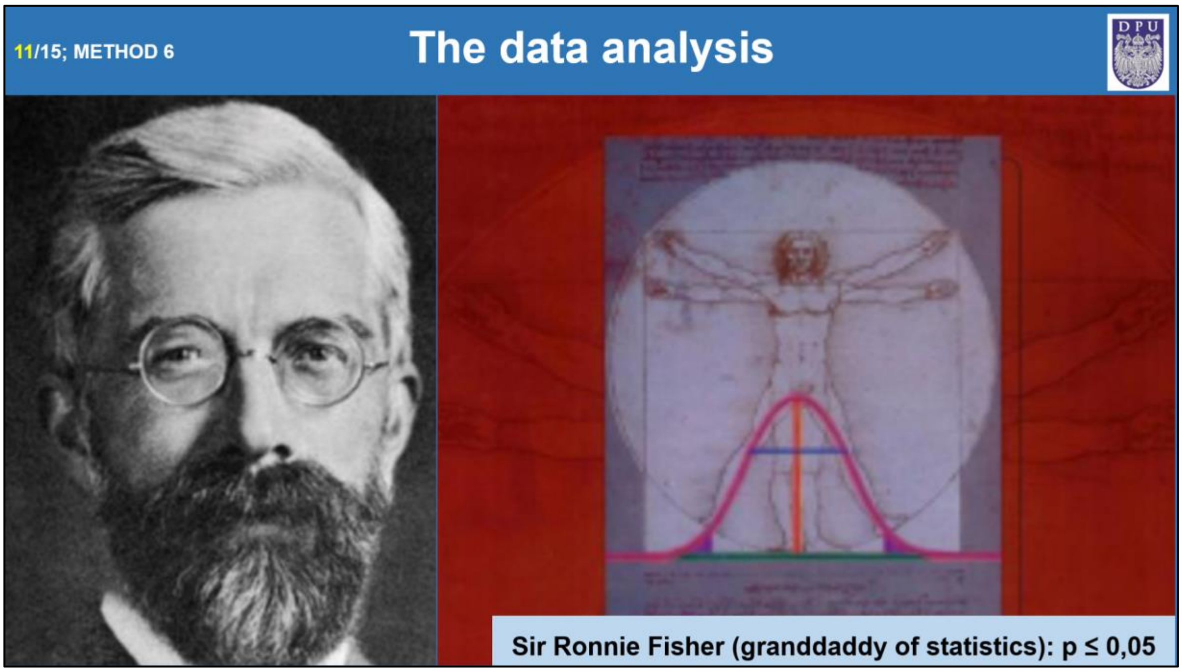


To my surprise, the measurement validity of my hand measurement was highly significantly (t-test) better than the measurement validity of the software, which is why from then on only the tooth widths measured by hand were used for further data analysis.

Double slide 11

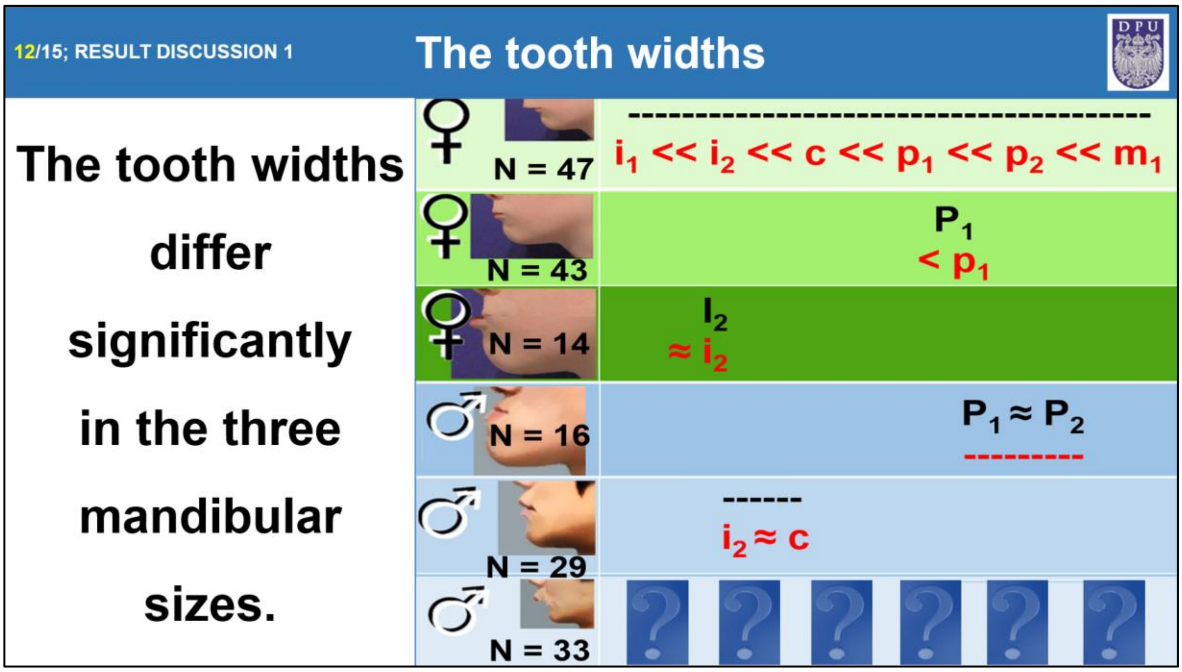


The data analysis was done by inductive statistics with the help of a accredited statistician and the programme SPSS®. In my case, this statistician was Professor Wilhelm Frank from Vienna. He used several mathematical tests to be able to distinguish random differences from non-random differences in the tooth width sum ratios.

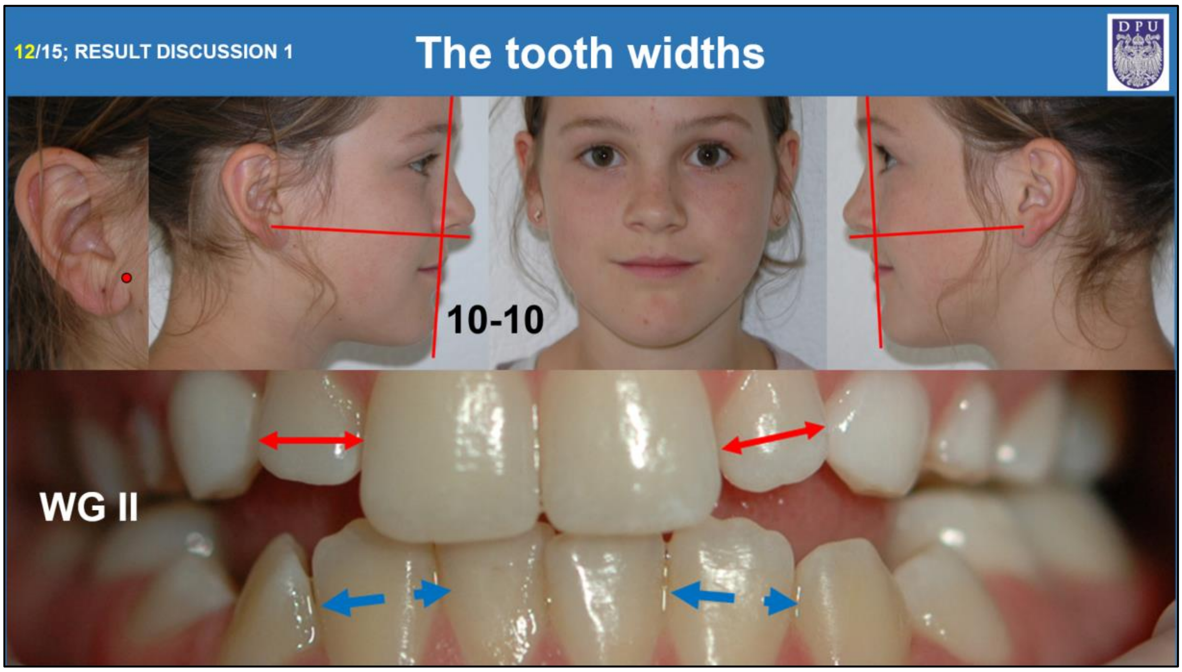


Professor Frank chose the alpha value of $p \leq 0.05$, which has been used since 1920, as the decision threshold for significance.

Double slide 12

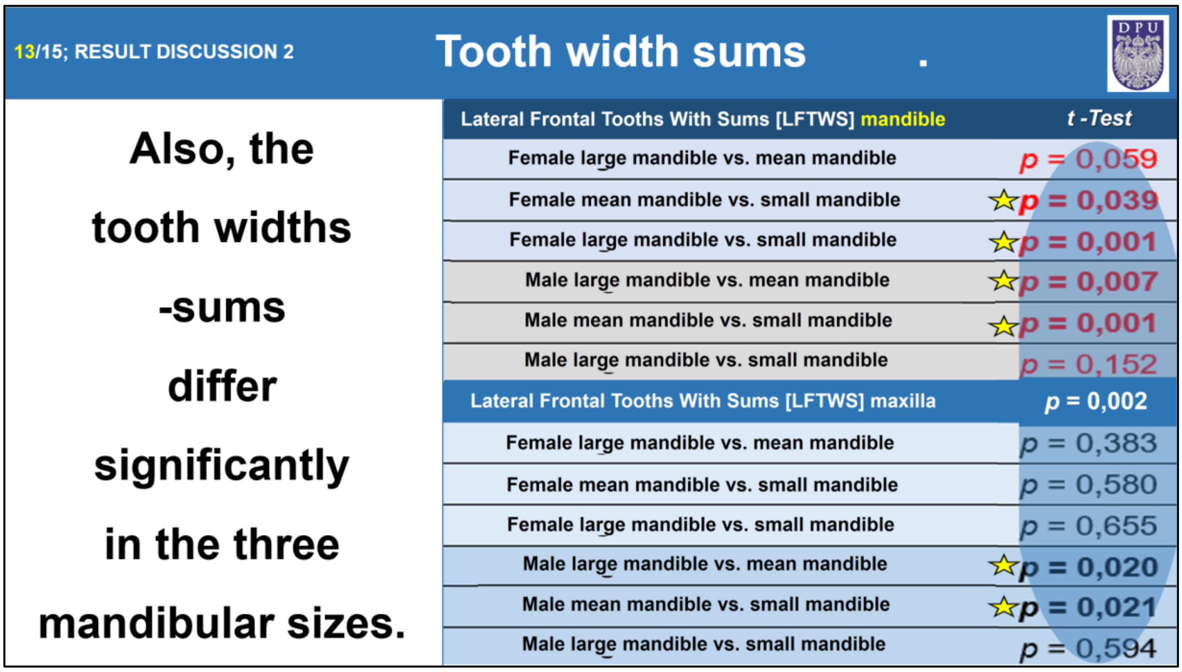


The tooth widths differ significantly in the three mandibular sizes. The tooth widths differ so significantly that they reveal unique tooth width patterns in subgroup comparisons. These tooth width patterns are useful to me in orthodontics because, in combination with the tooth width standard values of the individual tooth types, I can now assign the cause of disharmonious tooth sizes to one and/or both jaws.

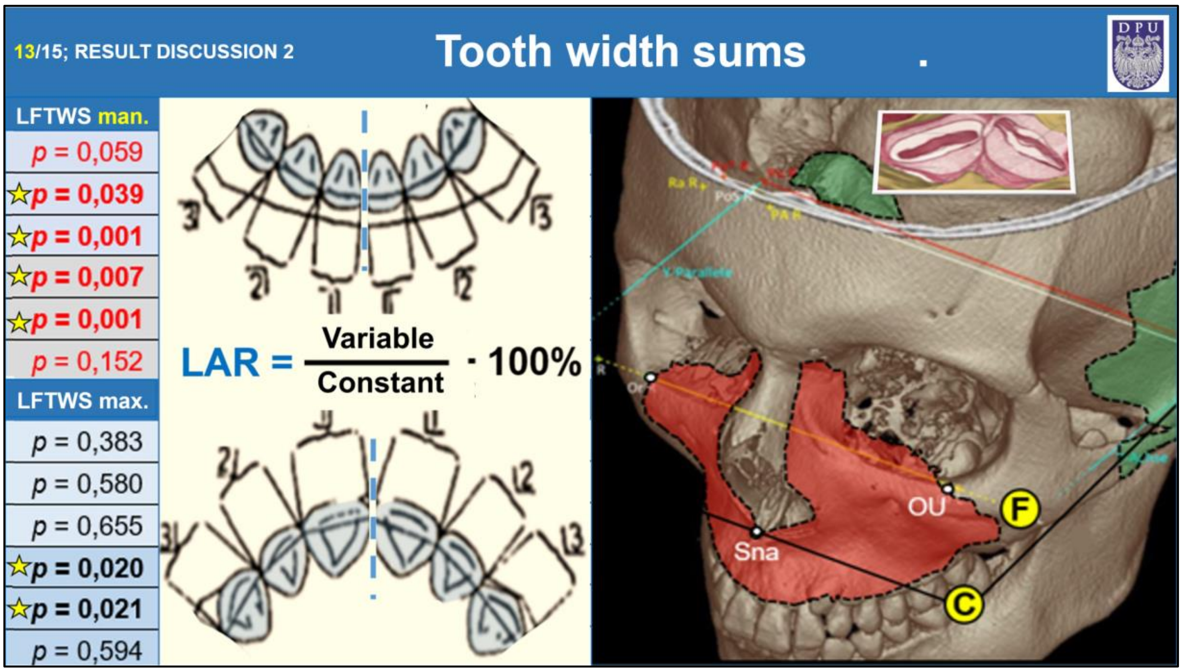


Unfortunately, I cannot explain the revealed tooth width patterns: This is because the men with small mandibles do not have their own tooth width pattern and thus no complete theory can be established. Presumably, the three-part mandibular classification was too little differentiated.

Double slide 13



The tooth width sums also differ significantly in the three mandibular sizes. The tooth width sums differ so significantly (p = 0,02) that a 73-year-old premise could be revealed with them in the jaw comparison. This revealed premise is of use to me in basic research because I have now confirmed the formula structure used and may therefore continue to use it.



I can explain the revealed premise at least theoretically: Assuming that there is contact inhibition of odontogenic epithelial cells, this should very likely be more common in the maxilla than in the mandible because, unlike mandibular growth, maxillary growth is enclosed by other skeletal structures and is therefore less influenced epigenetically.

Double slide 14

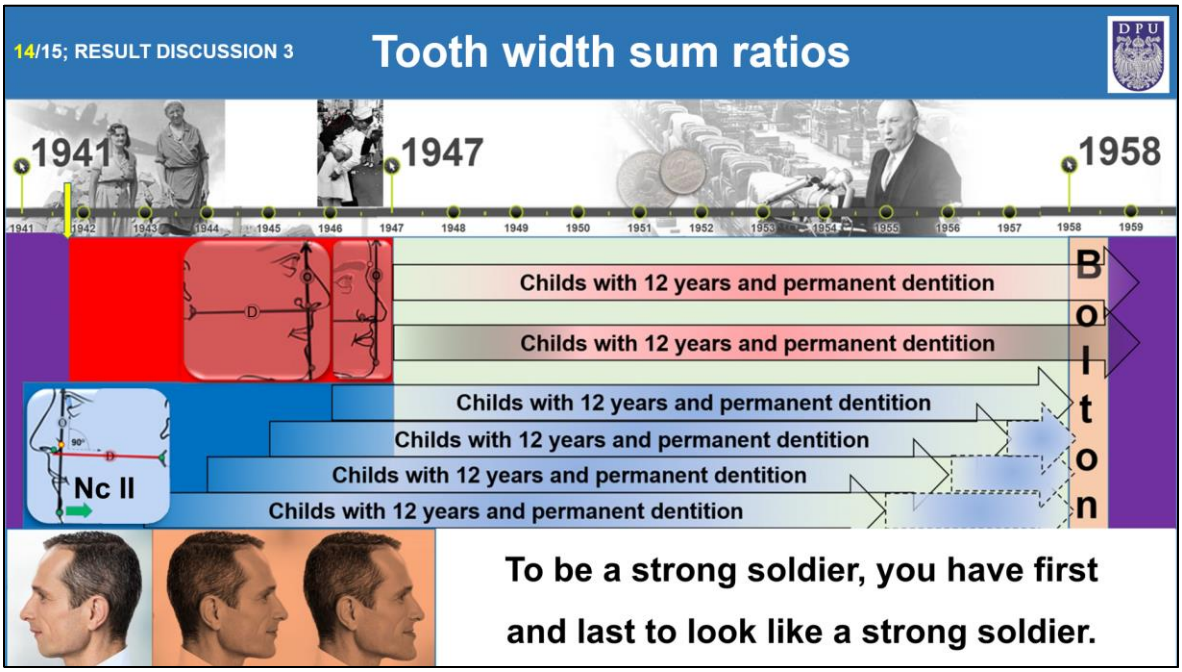
14/15; RESULT DISCUSSION 3

Tooth width sum ratios

Also, the tooth widths -sums -ratios differ significantly in the three mandibular sizes.

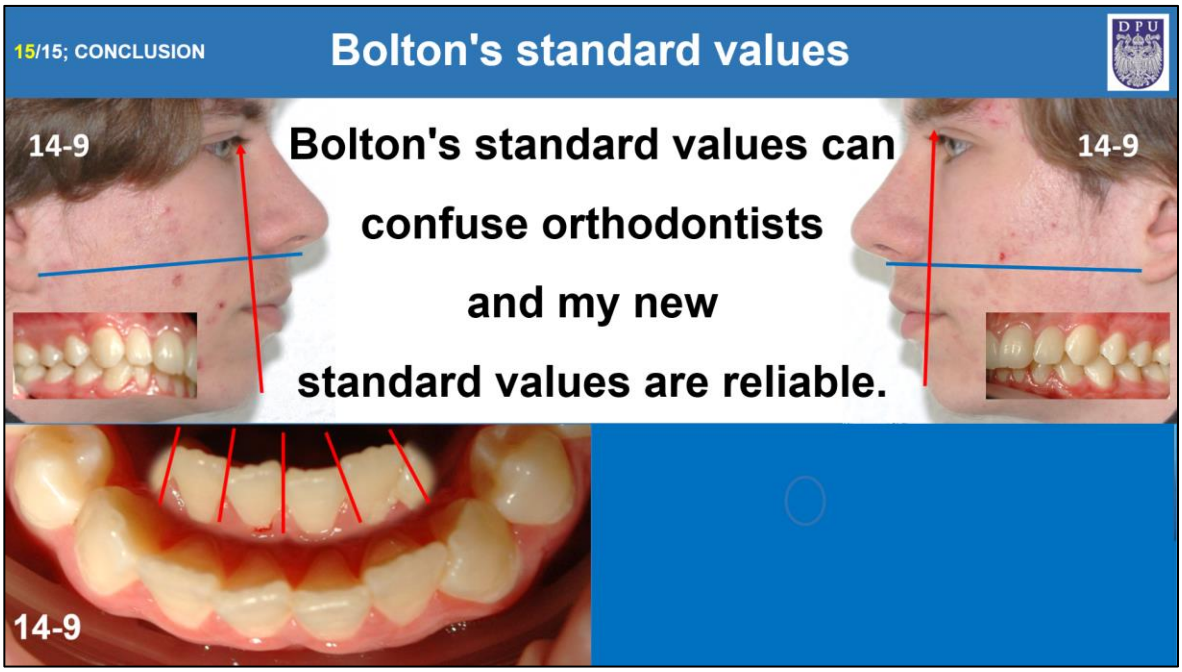
LAR's in comparison with 77.2%	N	Mean %	St. dev.	p-values	
Female patients with Nc II	47	76,4	± 2,7	0,031	*
Male patients with Nc II	33	77,5	± 1,7	0,323	NS
Female patients with Nc I	43	78,4	± 1,9	0,001	***
Male patients with Nc I	29	78,6	± 2,5	0,006	**
Female patients with Nc III	14	79,9	± 3,9	0,021	*
Male patients with Nc III	16	78,7	± 2,1	0,014	*
Female patients (all)	104	77,7	± 2,9	0,104	NS
Male patients (all)	78	78,1	± 2,2	0,001	***
LAR's in comparison with 91,3%	**N**	**Mean %**	**St. Dev**	**p-values**	
Female patients with Nc II	47	90,3	± 1,9	0,001	***
Male patients with Nc II	33	91,1	± 1,2	0,230	NS
Female patients with Nc I	43	92,3	± 1,5	0,001	***
Male patients with Nc I	29	92,2	± 1,2	0,001	***
Female patients with Nc III	14	92,8	± 1,7	0,007	**
Male patients with Nc III	16	92,2	± 1,5	0,023	*
Female patients (all)	104	91,5	± 2,0	0,162	NS
Male patients (all)	78	91,7	± 1,4	0,009	**

The tooth width sum ratios also differ significantly in the three mandibular sizes. The tooth width sum ratios differ so significantly that they could be used to uncover a randomisation error in Bolton's male pool when comparing patients. This randomisation error is useful to me in further training because I now have a better understanding of my norm values.

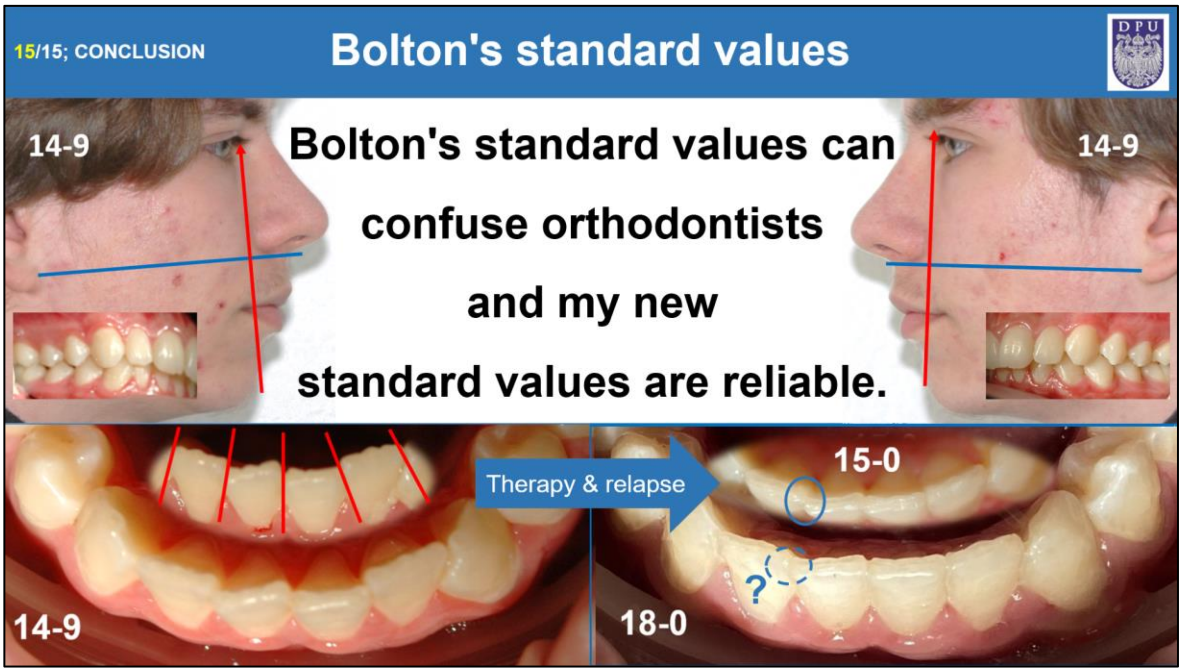


I can actually explain the randomisation error that was revealed: For the Second World War, it was primarily strong-looking Americans (large or medium-sized lower jaws) who were drafted into the military for the reconquest of France. As a result, their sons could not then be in Bolton's study because they were either still too young or they had to replace or at best nurse their deceased fathers at the age of 16.

Double slide 15



Bolton's norms can only confuse orthodontists and my norms are reliable. I can illustrate how strong my confidence in my norm values is with a treatment of my son. Three years ago, I resolved a crowding of his front teeth by reducing the size of the lower front teeth without knowing how much I should slice away and therefore I had one foot in jail because of the lack of a data pool or the corresponding study (a little joke at the end).



I am quite confident about the stability of the achieved goal because, surprisingly, it has been shown that a primary recurrence between teeth 41 and 42 recedes spontaneously and if I had already had my normal values at that time, there might not have been a recurrence in the first instance.

Single slide 1

Do you have any questions? Then thank you very much for your attention and come home safely.

Dr. med. dent Martin vom Brocke MSc   24.9.2021

AFTERWORDS

At WHEN is a toothbrace "not necessary", "recommended" or "necessary"?

To assess the need for treatment of malocclusions, the dentist should consider the three pillars of evidence-based dentistry: First, dental experience; second, patient preference; and third, studies. If none of these pillars support tooth braces, then braces are not necessary; if only one of these pillars supports the correction of a malocclusion, then braces are recommended and in all other cases the correction of a malocclusion by braces is necessary (Fig. I).

Figure I: ***On the need for treatment.*** In my 24 years of experience as a dentist, the most common dental malocclusion is undoubtedly crowding in the mandibular anterior region and oral hygiene tends to be less consistently done there because of the additional difficulty of access, which more often leads to gingivitis and ultimately bone loss if professional dental hygiene is not also regularly performed. Because there is a reliable study on this (BAGHDADI, 2019, Bone loss and crowding in the mandible. Dissertation. University of Bonn.), which largely confirms my experience, I can tell the patient: here, the resolution of the crowding by braces is necessary. However, if the therapy result can only be stabilised with a subsequent fixed orthodontic retainer, then this artificial cleaning obstacle again increases the risk of periodontal disease (periodontitis). Then the first pillar for evidence-based dentistry no longer applies. There is no study that shows that retainers are not an obstacle to cleaning. Therefore, braces are only recommended if the patient can successfully perform oral hygiene despite the retainer.

What are the basic considerations of the structural theory of gravity?

66 million years ago, an asteroid about 15 km in diameter hit the Earth in Yucatan, the impact force and dust generation of which led to the disappearance of a morphologically independent group of species - the dinosaurs (WIKIPEDIA, 2021). However, this theory does not explain the survival of other animals in the same epoch. What is certain is that the larger and more numerous impacting asteroids are, the more rapidly the mass of the Earth or its gravity increases. L. PERIVOLAROPOULOS (Department of Physics, University of Ioannina, MNRAS 000, 1-9 (2022)) confirms in 2022 that the extinction of the dinosaurs could be the result of an increase in gravity. It is possible, for example, that the mouse macaques - ancestors of primates and thus also of humans - which weighed almost 50 g and jumped from branch to branch about 80 million years ago, consisted of more fractals that matched a greater gravitational pull and thus survived the 66 million year mark. Mouse macaques already had hands with four fingers plus thumbs, human-like ears as well as balance ability and it is conceivable that a heritable gravitational adaptability shapes humans in such a way that we can recognise a kind of gravitational shadow on us (**Fig. II**).

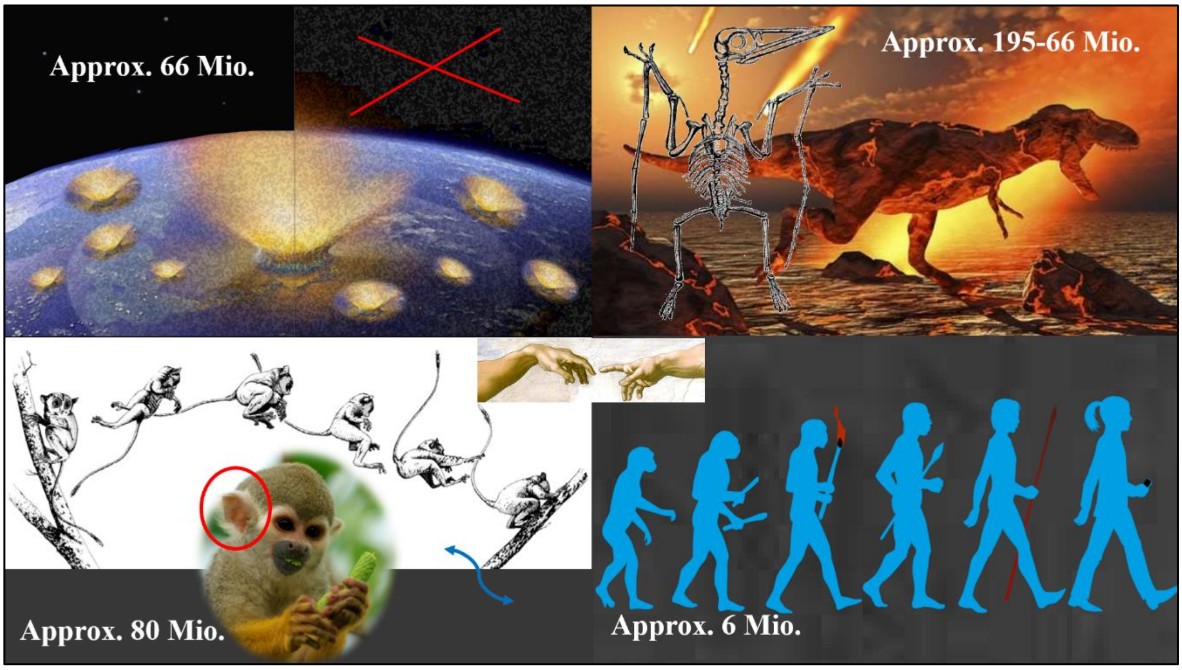


Figure II: ***Structural theory of gravity.*** Since asteroids only fall onto the Earth and are not hurled away from it, an increase in the mass of the Earth or its gravity must be assumed. Species whose support structures can adapt to the gravity that permanently surrounds them have an evolutionary advantage. It is conceivable that the DNA stores a kind of "gravitational shadow" in the cartilage tissue, which we can recognise in ourselves.

Why is the result found important for anthropologists?

That there may be a coincidence between facial geometry and tooth widths has long been suspected, but has never been confirmed with blinded methodology in living humans. Now, tooth width pattern changes can be used to draw conclusions about dietary habits and facial changes in relation to population groups (**Fig. IV**).

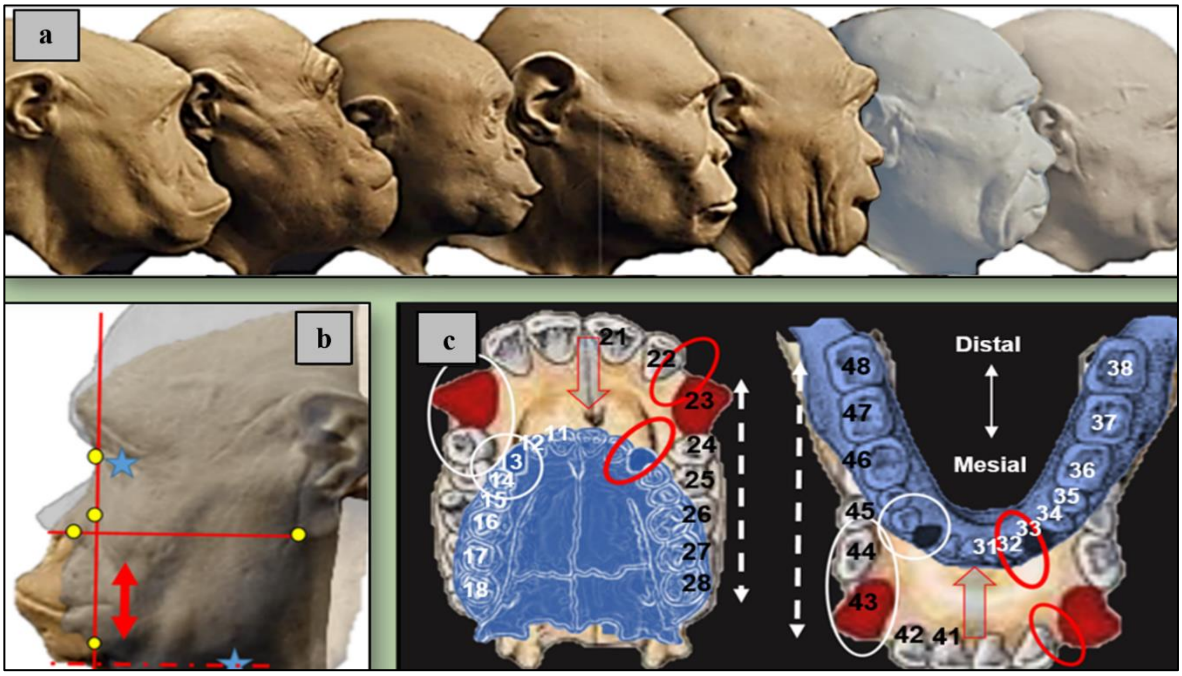


Figure IV: *Anthropological significance.* The schematic drawing illustrates a plausible explanation why tooth widths vary more in the mandible than in the maxilla. The maxilla is more embedded in its environment than the mandible and is therefore less influenced by epigenetic eating habits than the mandible, which is held in place by the masticatory muscles.

What use is representative mathematics for human medicine, for example?

All functionally healthy living organs integrated in an organism have primarily exponential growth and converge towards a structural limit value in a genetically controlled manner at a speed that can be represented mathematically by the zeta function, for example. This is exactly what malignant tumours do not do, although they are in principle also a fractal of the original body cell. If we know the growth rate of a tumour, we know more about its character and can therefore possibly find the right drugs that can specifically slow down just this one growth rate. Representative mathematics could also be used to estimate the biological age of a patient or even of an unknown cadaver, if appropriate standard values are available (**Fig. III**).

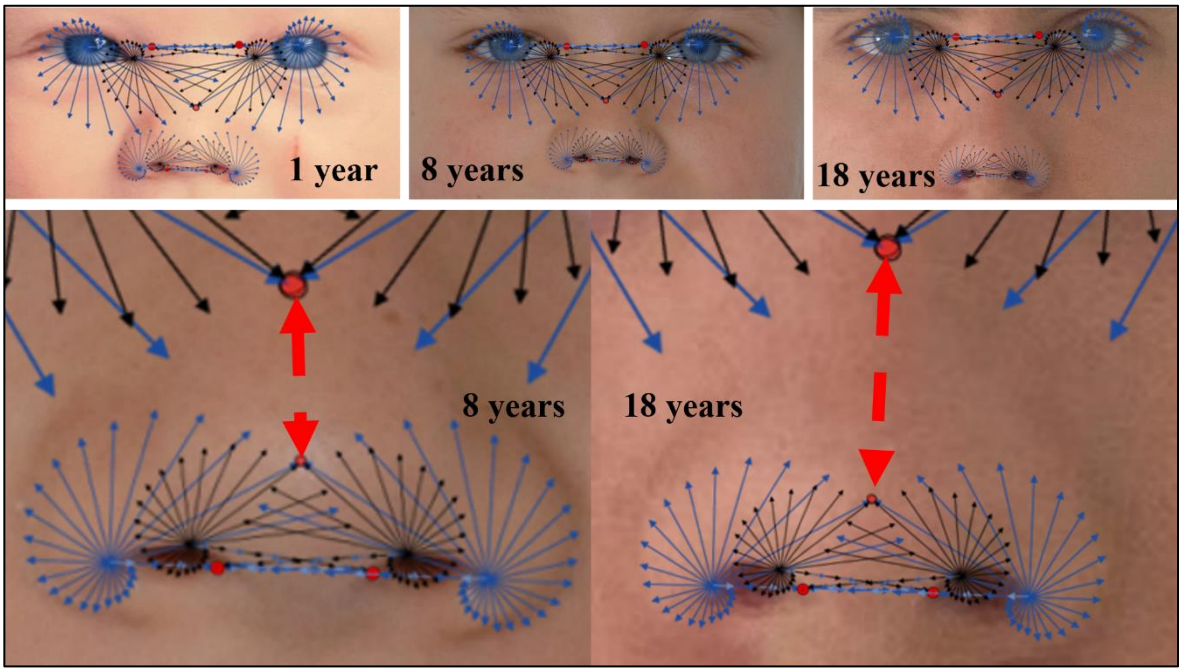
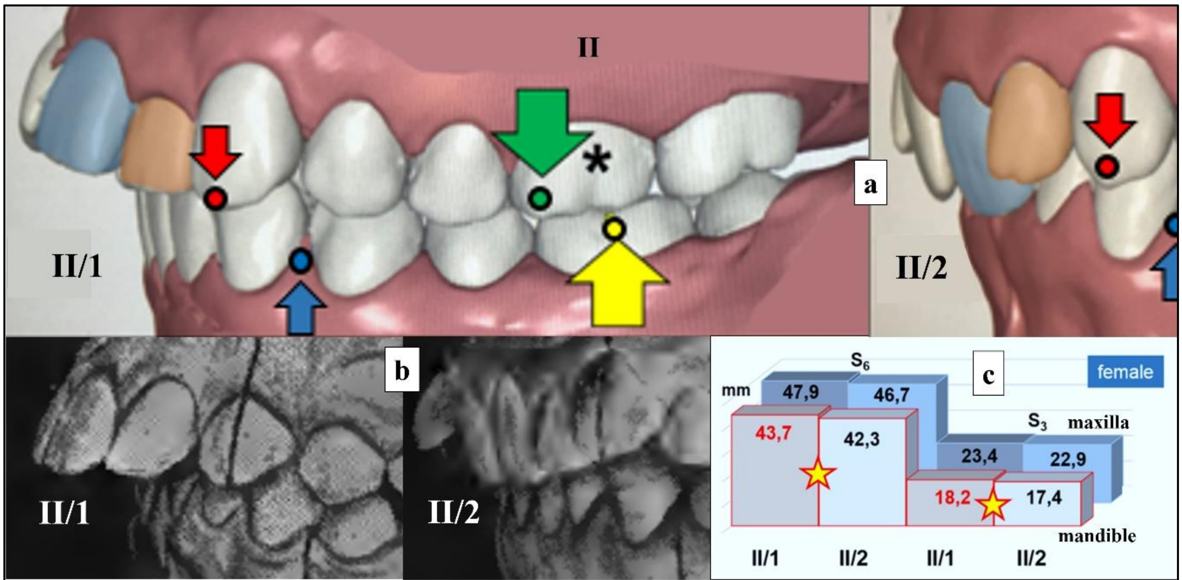


Figure III: ***Medical benefits.*** If the regularity of the growth rates of all individual organs is known, medicines can be created which can be delivered to patients at the optimal time - different growth situations. For example, the facial spiral can be used to assess the age of the patient by evaluating the vertical growth of the nose, which changes over a lifetime.

Why is my PhD not published in an orthodontics journal?

In the course of my science studies, we had recurrent study clubs in the presence of the six of us PhD students, our supervisors and the director of studies. On one of these occasions (January 2020) I pointed out that ANGLE (1899) had neglected latera-lity in his classes I und III and had thus made a mistake. However, to say this publicly is delicate because in 1907 in the USA the Society of Orthodontists had agreed that the Angle classes should be used as a basis for orthodontic research. If it becomes known that this contains a therapy-relevant error, then recognised professors fear that they will be sued. This is nonsense, of course, because I had specifically only investigated whether the ZBSn in patients with an Angle class II/1 differed from those with an Angle class II/2 and the result revealed two significant differences in all and anterior teeth ($p \leq 0.05$) in females (**Fig. V**).



From EH Angle 1907: Treatment of malocclusion of the teeth. Angles system. Philadelphia. The S.S. White Dental Manufacturing Company. S. 50
"Division II/2 is characterized specifically also by distal occlusion of the teeth in both lateral halves of the lower dental arch, indicated by the mesio-distal relations of the first permanent molars, but with retrusion instead of protrusion of the upper incisors."

Figure V: Angle class II/1 and II/2. (a) shows schematically the three Angle classes, which are inconsistent with regard to laterality: Only in the case of class II is the laterality problem addressed. (b) from EH Angle (1907) also shows the poor discriminatory power of his classification.

The individual patient sides were examined separately according to their classification – the data sets were blinded – and forwarded to the statistician for analysis. This revealed that in the female patients in the mandible, both the lateral anterior width sums and the total tooth width sums were on average around 1.5 mm greater in Angle class II/1 than in class II/2.

Although I have taken care in my Ph-Dissertation not to provoke any orthodontic diagnosis, it is impossible to publish my work regularly in an orthodontic journal, as demonstrated e.g. by an e-mail with Professor Eliades – Professor of Orthodontics at the University of Zurich – (Fig. VI), because there is no peer reviewer who would like to discredit the work of E.H. Angle (1899).At the universities, clinical orthodontic diagnostics is completely neglected because it is easier as a professor to conceal the truth than to represent it.

Von: Eliades Theodore
Gesendet: Montag, 1. November 2021 07:25
An: Martin vom Brocke
Betreff: RE: Prof. Bockstein can't help me

Dear Dr. vom Brocke

I am sorry that this did not work-perhaps you should take the advise of F. Bookstein.

Hiring you at UZH has the following drawbacks: first it does not solve the problem of finding a source to validate the work through publication in a peer review journal. Second it is outside of the scope of our research activity and interest and won't contribute anything to our undergraduate or postgraduate program-at this stage sat least where your work remains as unpublished data. Also SNF-funded positions is not as easy as you think and in the past there has never been a case at ZZM that we hosted an SNF-paid staff member. And at any rate we cannot employee somebody without a salary.

I still believe that you should seek: a. publication in a relevant (anatomy, orthodontic) journal through the collaboration with your advisors of your doctoral degree thesis; b. write to the suggested source by Prof. Bookstein.

Best wishes and good luck in your efforts

TE

Abbildung VI: Korrespondenz mit Professor Eliades.

I offered Professor Eliades to work without a salary because the university was supposedly planning to cut funding and he could not offer me a job for that reason, among others. He advised me to activate the Swiss National Fund [SNF] because of the "necessary" funding. I then phoned Dr C. Meier from the SNF. He said that I would have to get a 50% position at the University of Zurich before they would consider supporting me. This means that even though my research, which enables x-ray-free initial diagnosis and solves an ethical dilemma about orthodontic retainers, is not funded due to outdated administrative reasons. So now I have to "find" a centre for dento-facial diagnostics myself, where patients can obtain a second opinion at low cost and at the same time make their data available for corresponding publications. But who finances the necessary equipment and premises? The SNF?

What ethical dilemma does the fixed orthodontic retainer pose?

It does not require a study but only plausible thinking to understand that today – in the age of Corona – it is hardly ethically justifiable to insert a fixed orthodontic retainer after resolving a mandibular anterior crowding. As above-mentioned, this retainer is a foreign body in the mouth, which can only be freed from tartar with professional help. What is new since 2018 is that this tartar – tartar can form anew within two weeks – can not only hide living bacteria that are inaccessible to antibodies, but also the 1000 times smaller and potentially deadly coronaviruses. Once these have taken up residence, they do not cause any noticeable harm to an immunocompromised young person, but they can reach older relatives at any time via the droplets in the air and cause them considerable harm (**Fig. VII**).

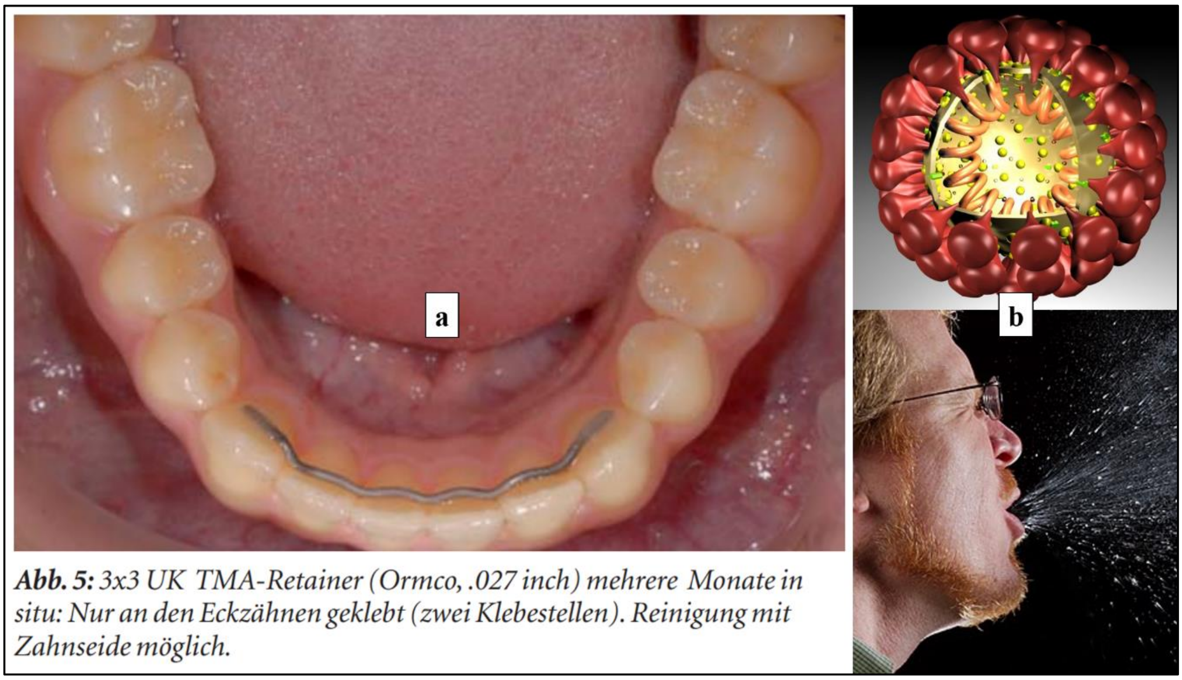


Figure VII: Fixed orthodontic retainers: The information taken from the publication by R. Meyer (Fixe orthodontische Retainer - eine tickende Zeitbombe? DENTAL TRIBIUNE Swiss edition. 11:2021) (**a**) shows a fixed orthodontic retainer. Figure (**b**) from WIKIPEDIA shows the connection between droplet infection by covid viruses originating from the oral cavity.

R. Meyer published in 2012 (Fig. VI) that the teeth can be cleaned with dental floss when retainers are only attached to the canines. It is typical that the orthodontist does not mention that the retainer itself cannot be flossed. Dear SNF: This concealment **signals helplessness**.

Why should orthodontics have been supported for a long time?

I answered this question two times in 2016 (Struktur; ISBN 978-3-945127-08-7; Tooth Orthopaedia ISBN 978-3-945127-12-4) or SCHUEZ I. and 2021 ALT K.W. (Leonardo da Vinci and dental anatomy; Journal for Anatomy) with the words: "Leonardo da Vinci also recognised the connection between form, function and strength of the teeth. Had Leonardo da Vinci's anatomy textbook been published as planned, its importance to dentistry would probably not have been overlooked."In 1489, for example, Leonardo da Vinci wrote, among other things, on a sketch of a dissected skull (RCIN 919058v): "The cavity of the eyes, the cheekbones, the nose as well as the mouth are of equal depth and end in a vertical line below the common sense" (**Fig. VIII**).

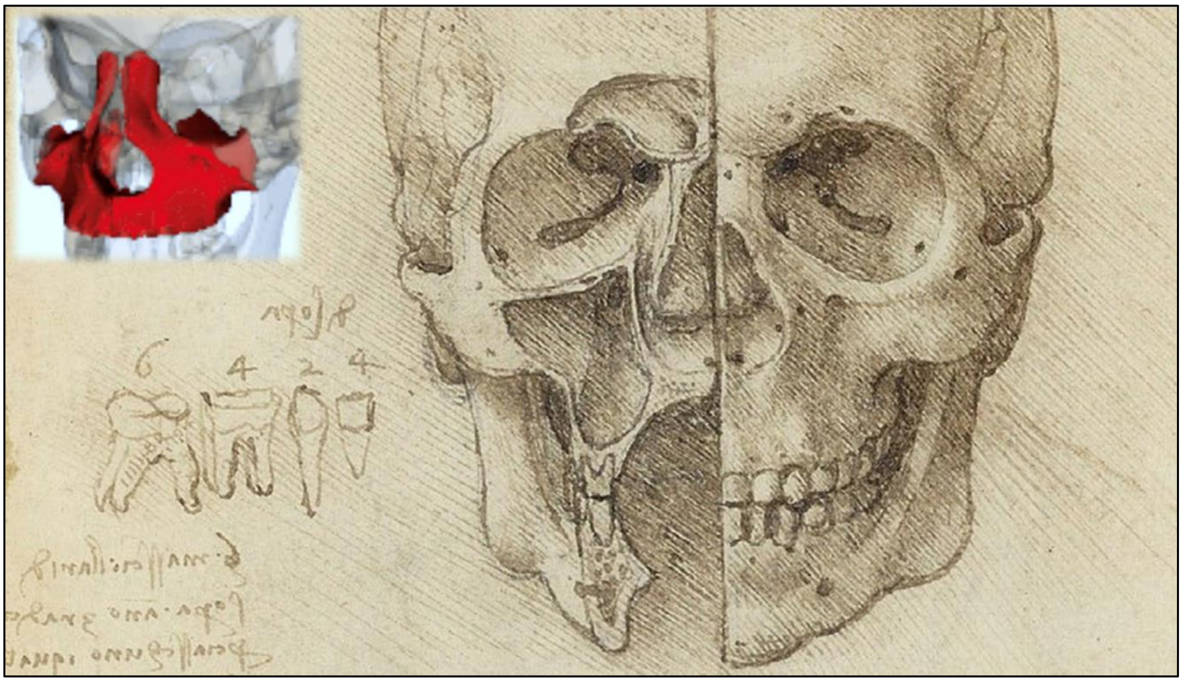


Figure VIII: The dissected skull: Leonardo da Vinci's illustration – here supplemented by colour – shows how he had described the upper jaw through the cavities surrounding it and recognised a morphological orthogonality to the first premolar as well as numerical tooth width ratios.

Figure VIII allows the interpretation that L. da Vinci gave central importance to the upper jaw and saw in it a diagnostic basis for orthogonally positioned teeth. This contradicts what E.H. Angle published in 1906. He proclaimed that the first upper molar was the diagnostic basis for orthogonally standing jaws. Since then, the pursuit of the purpose of orthodontics has been based on his trival assertion, because there is no competitive classification based on a genuine advanced scientific theory.

Who helps to form a sister society to orthodontics?

We, Dr. sc. nat. ETH Peter Wildhaber (physicist) and I are founding with this book a simple personal sister society to that of the orthodontists, whose contributed capital is personal skills, contributions in the form of lectures or simply sociability for community preservation. Our headquarters is in "neutral" Switzerland, its name is Dental Orthopedic Community [DOC], its logo is the butterfly in the tooth and its scientific basis is based on the realisation that gravity enables harmonious growth (ζ4*)* thanks to 4D clustering and lateralised functional balancing (Fig. IX).

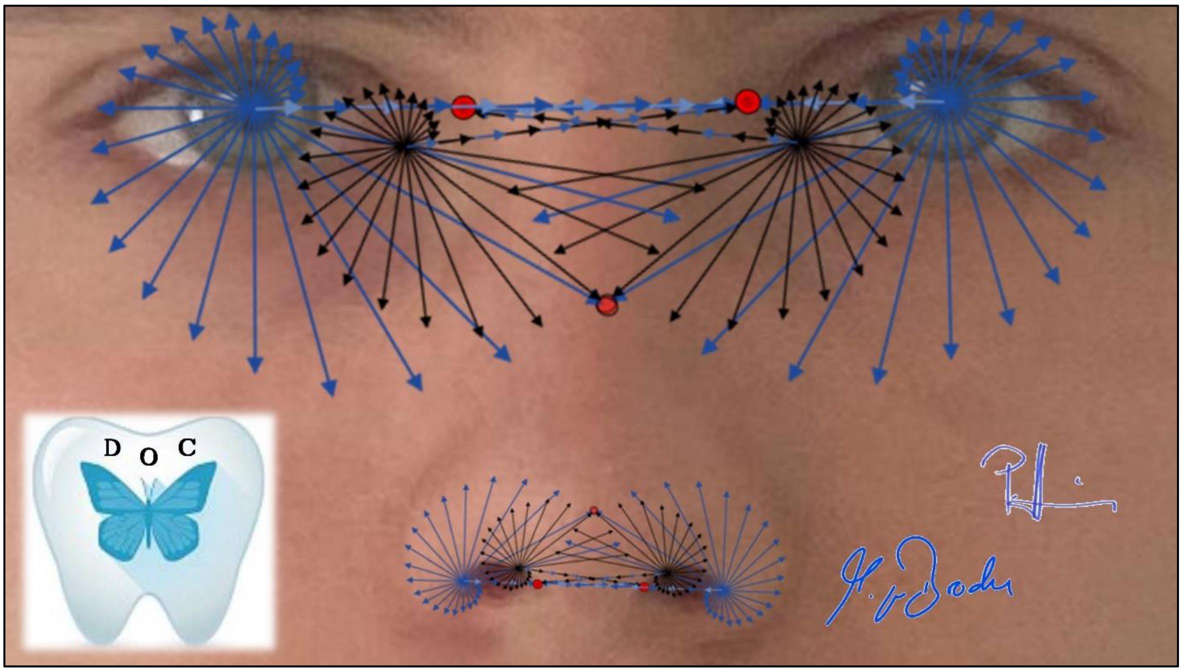


Abbildung IX: Figure IX: *ζ4$_{(n=24)}$*[24] as the scientific basis of the Society for Orthodontics. Here, for example, the struction spiral is used to assess vertical maxillary development.

We pursue the goal (purpose) of publishing an international journal for dental orthopaedics with original scientific articles on dento-facial diagnostics in relation to the scientific basis of the structural theory of gravity (ISBN: 978-3-945127-38-4) and the facial discrimination level D as a reference. It should be possible to publish or discuss randomised cephalometric comparative studies [RCT] as well as orthodontic case presentations, where it does not matter where they were done, but how they were done: Reproducible Methodology. The articles go through a peer-review process, which also guarantees data anonymisation. If you are interested in becoming a member, please write to: martin@vombrocke.ch.

What neutral bite does tooth orthepedaedics advice as a therapeutic goal?

Statistical analyses of occlusal coincidences in relation to the morphological maxilla revealed that the first premolars are very well suited to define a diagnostic neutral bite that is valid for all jaw sizes (**Fig. X**).

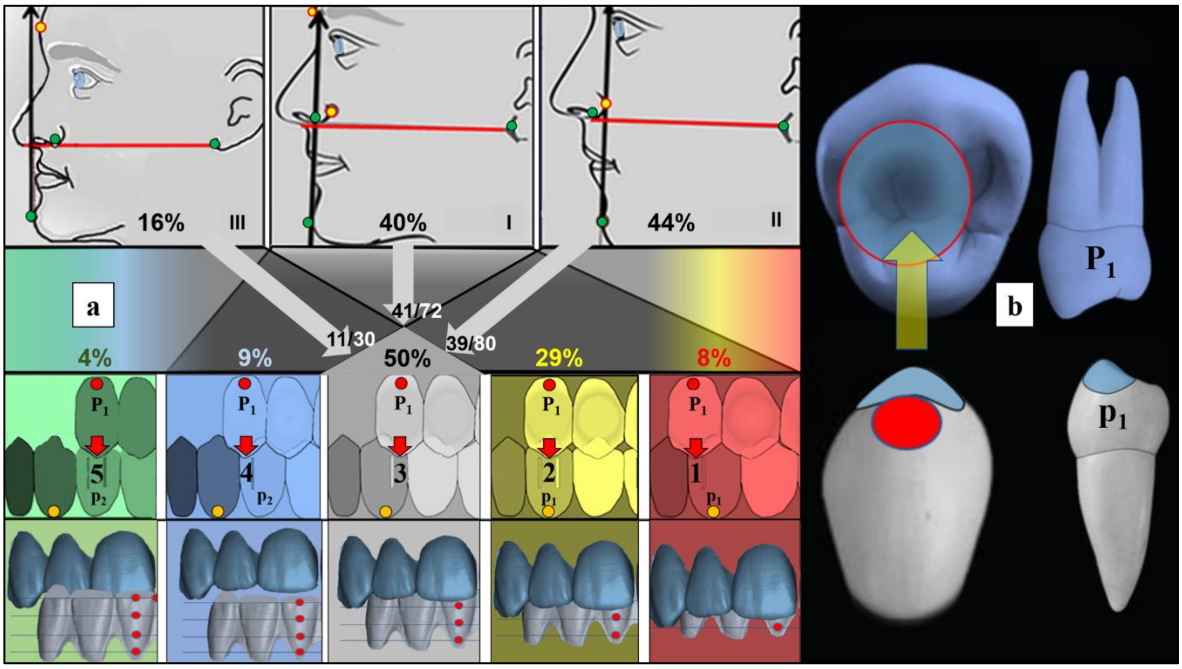


Figure X: The tooth orthopaedic neutral bite. Figure (**a**) shows that in all jaw sizes the lower first premolars [p_1] bite on the upper first premolars [P_1] with a probability of approx. 50% in such a way that a premolar class 3 [= primary scientific neutral bite in orthodontics: the supporting cusp tip of p_1 bites on the mesial occlusal surface of P_1] is present and at the same time there is an anterior overlap in the incisal third of the anterior teeth. Figure (**b**) shows schematically that a scientific neutral occlusion and a therapeutically stabilised neutral occlusion do not have to be the same. If, in the case of a premolar class 2, the central enamel ridge of P_1 is ground away, this also results in a stable neutral bite in the premolar region, if care is taken at the same time to ensure that no lateral balance pre-contacts remain. In premolar class 2, a slightly deeper anterior overlap is to be expected, but this is not a problem.

The first premolar as an orientation tooth for a diagnostic "neutral bite" has the advantage over the first molar that it is in its definitive position sooner than the first molar. E.H. Angle and the Society of Orthodontists did not know at the beginning of the 20th century that the first molars do not remain in their definitive position until the second premolars, which erupt after the first premolars, have broken through. This leeway reaction, which is 1 mm more pronounced in the lower jaw, must be dismissed by orthodontists as insignificant because they cannot make themselves look bad.

Do the class frequencies of dental orthopaedics and orthodontics differ?

Yes, unequivocally: This is revealed when the PhDs models or their Angle classes and three premolar classes - both of which can in principle be assigned to orthodontics - are compared with the Norma classes of tooth orthopaedics (**Fig. XI**).

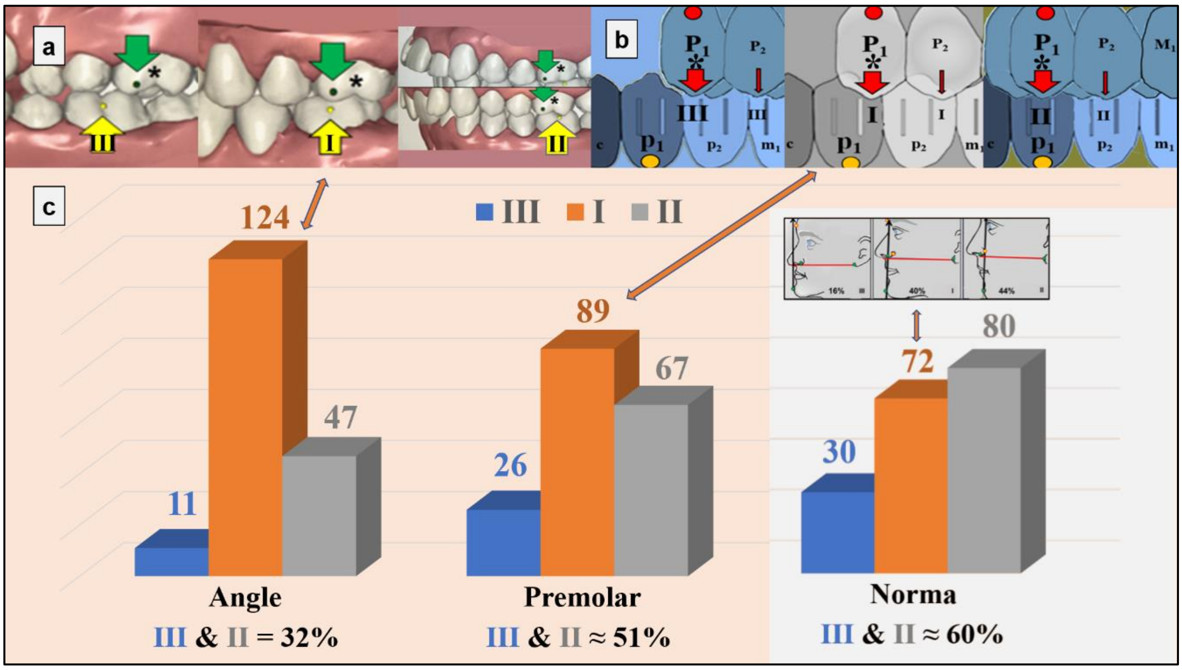


Figure XI: Distribution frequencies. (**a**) shows the distribution frequencies in the three Angle classes after orthogonally focussing on the buccal surface of teeth 16 and 26. (b) shows the distribution frequencies in three Premolar classes after orthogonally focussing on the buccal surface of teeth 14 and 24. Figure (c) shows the distribution frequencies in the three Norma classes.

The result of a clinical study usually forms the basis of a therapy in relation to the selected sample - in this case, all the proband had a malocclusion, which was then also corrected -. The distribution frequency of the angle classes leads to the legitimate interpretation that approx. 32% of all malocclusions coincide with an abnormal mandibular position (class II or III), or that the mandible should therefore be shifted. The result for the premolars leads to the interpretation that even in 51% of the same patients the mandible should be shifted. In the end, however, the mandible was surgically moved in only one patient and only the teeth were moved in all other patients. The result on the Norma classification shows that 60% of all malocclusions also coincide with an unusually large or small mandible, whose tooth widths vary significantly more than in the maxilla. This allows for therapeutic tooth resizing and/or shifting: Dental orthopaedics.

What is the relevance of harmonically clustered growth – struction –?

In general, without harmoniously clustered growth, our lives would be syndrome-like and a structured society would be unthinkable (**Fig. XII**).

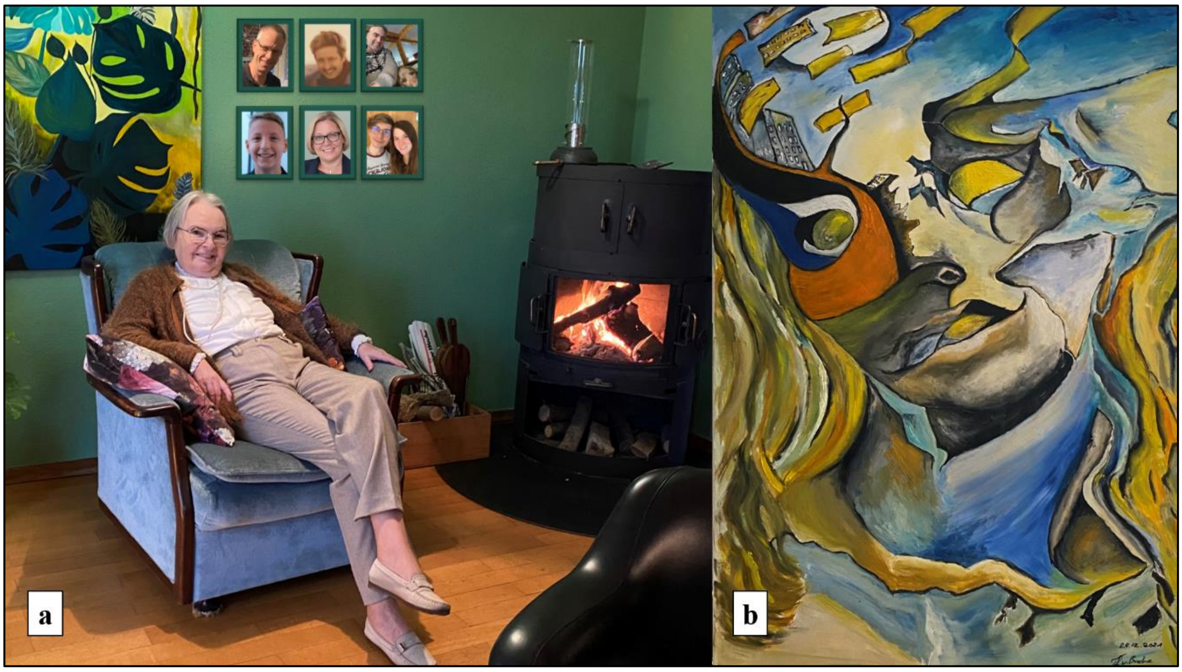


Figure XII: Struction (a) vs. syndrome (b). (**a**) shows my mother enjoying the 24th of Dec. 2021 and (**b**) shows a painting - syndrome - done by my brother for this book.

Specifically, the importance of harmonically clustered growth is evident in this book, which was written during the years of the Covid pandemic: The Norma classification is the diagnostic basis in tooth orthopaedics, just as the Angle classification is for orthodontics. Unlike orthodontics, however, it can offer standard tooth width values that legally permit therapeutic reduction of the lower anterior arch, which in turn allows the fixed orthodontic retainer to be omitted, thereby legitimising the need for braces in patients with anterior crowding. It protects our society because it helps to fight the civid pandemic. It is uncertain whether the Swiss National Science Foundation will fund tooth orthopaedics, as its statutes state that it only funds what our universities are already investigating – our NF apparently funds madness –.

If even one dentist leaves out a retainer because of this book, and because of that one person close to that orthodontic patient lives on, my efforts will have been worthwhile, because as a citation from the Talmud says: "*Whoever saves a single human life saves the world*."

Was sagt Prof. Dr. Theodore Eliades der UZH zu diesem Buch?

After I had sent the first edition of this book to Prof. Eliades (orthodontist, uUniversity of Zurich) on 25 December 2021, I received a corresponding reply already the following day, which encourages me that all my work - not like Leonardo da Vinci's - is receiving attention in dentistry and medicine or was not in vain (**Fig. XIII**).

Von: Eliades Theodore
Gesendet: Sonntag, 26. Dezember 2021 07:23
An: Martin vom Brocke
Betreff: Re: E-book vom Brocke as a Christmas present to all who areinterested.

Dear Dr. vom Brocke

Many thanks for the wishes and the kind gift. I hope that it receives the attention it deserves.

best wishes for a prosperous new year

T.E.

Theodore Eliades, DiplDS, MS, Dr Med Sci, PhD, DSc, FIMMM, FRSC, FInstP, FDS RCSEd
Professor and Director,
Clinic of Orthodontics and Pediatric Dentistry
Center of Dental Medicine, University of Zurich
Plattenstrasse 11, CH-8032, Zurich
tel +41 44 634 32 10/11
theodore.eliades@zzm.uzh.ch
www.orthodontic-biomaterials.ch

From: Martin vom Brocke <martin@vombrocke.ch>
Sent: 25 December 2021 15:59:32
To: Eliades Theodore
Subject: E-book vom Brocke as a Christmas present to all who are interested.

Dear Professor Eliades,

First of all, Merry Christmas and all the best for the New Year.
I have published my work as an e-book (in German) and attached it to you as a Christmas present. I am still working on the translation into English at the moment. Please feel free to forward this to interested readers as we may be able to contribute to the containment of the covid pandemic.

The book is primarily addressed to the Swiss National Science Foundation, in the hope that I can make a difference to dentistry as a whole. We shall see.

So, all the best,

Yours sincerely

Martin vom Brocke

Figure XIII: Attention recommended. Prof. Eliades recommends the attention of my first edition.

What can I do about Covid-19 in our society?

Braces are oral hygiene obstacles and because it could be that Covid-19 viruses also multiply in bacteria of the oral cavity, orthodontists should be urged to dispense with fixed orthodontic retainers. However, because orthodontists cannot do this because of their diagnostic credentials and because there are no competing companies that can do this, I have been offering myself as an orthodontic educator since 2021 so that patients and colleagues have someone to turn to if they have questions (**Fig. XIV**).

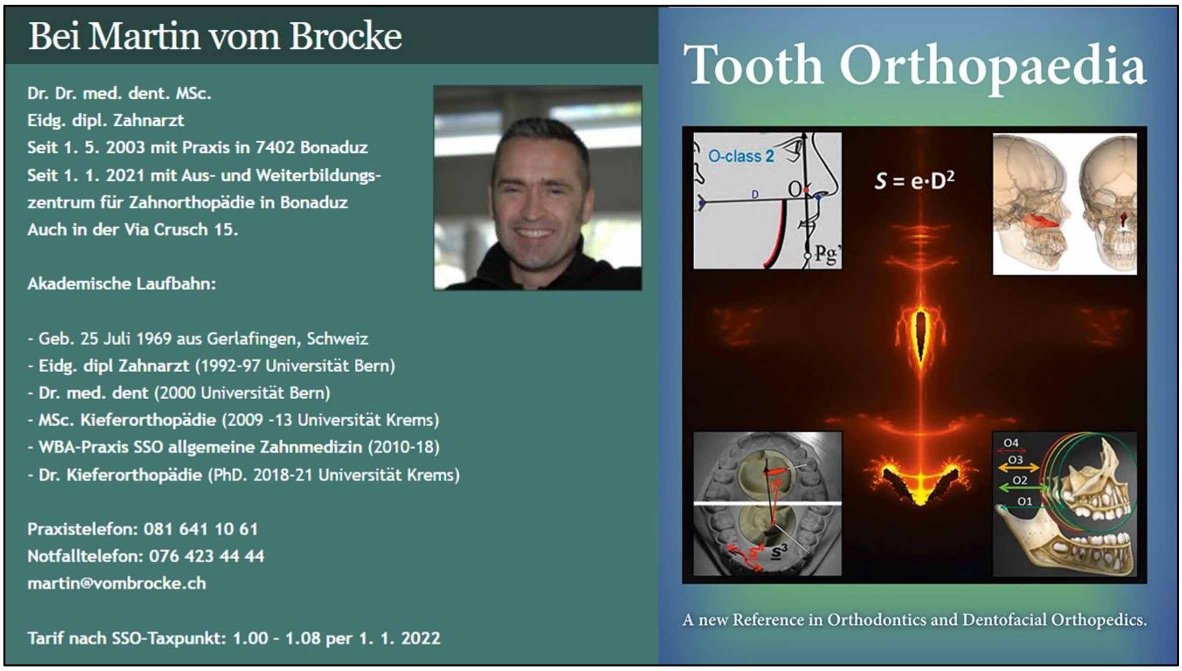


Figure XIV: A training and further education centre for dental orthopaedics. The figure shows an excerpt from my homepage and the five other book publications on whose data the Education and Training Centre for tooth orthopaedics is based.

Running a dental orthopaedics education and training centre is extremely low-cost thanks to online lecturing (zoom®) and does not require any support. On the other hand, a well-founded dental orthopaedics centre needs a suitable science centre. I own an old medical practice in Gerlafingen, which I could rebuild if someone would support me with 1'000'000.- sFr. This person would get back a company which would be a real alternative to that of orthodontics and could carry out therapies as well as a wide variety of research work. However, as I do not know any wealthy investors, this remains a wishful dream and there is only the hope that the planned journal for dental orthopaedics will at least receive attention abroad.

Why do I turn to the SNF with my dental orthopaedics?

On the front page of the Swiss National Science Foundation's homepage, the four sentences are written: "We invest in researchers and their ideas. *The Swiss National Science Foundation (SNSF) supports outstanding research at universities - from physics to medicine to sociology*. *Thousands of teams create knowledge for a better future for all people*. Together with our partners, we are shaping Switzerland as a research location" (**Fig. XV**).

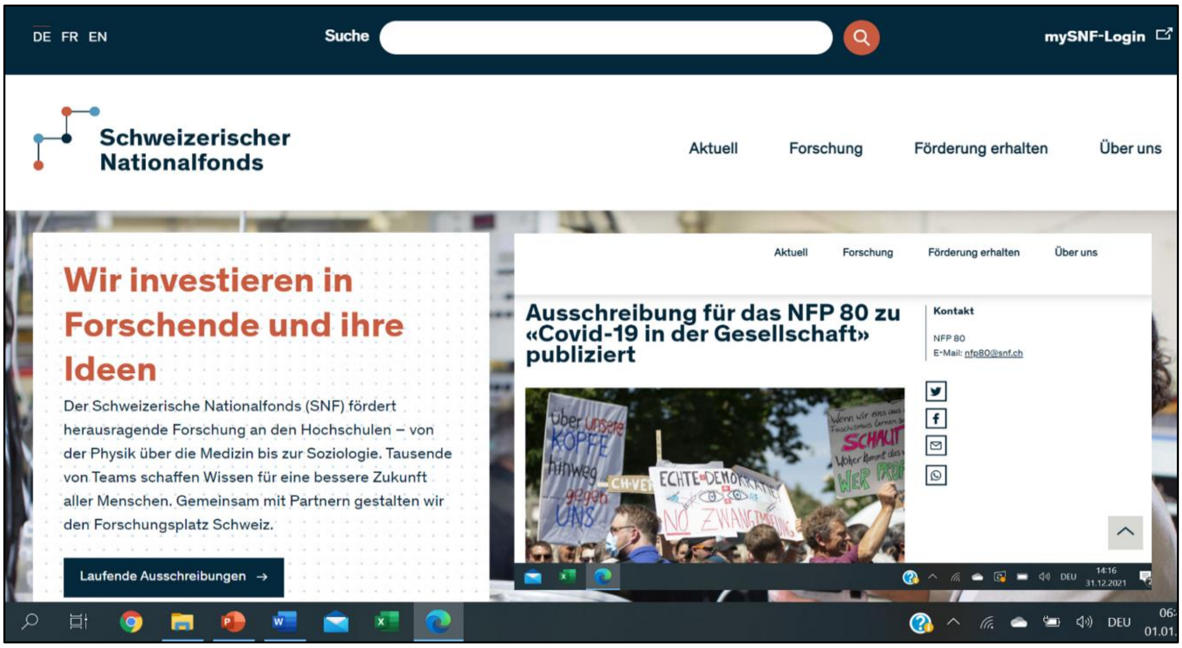


Figure XV: Swiss National Foundation SNF. HP front page & call for proposals page for Covid-19.

Regarding the first sentence: The fact that I am a researcher with my own ideas is proven by my five books from 2015 to 2018 as well as this book.

Regarding the second sentence: My philosophical dissertation received the rating "outstanding" summa cum laude and encompasses physics, medicine and sociology in equal measure. Unfortunately, there is no place to go in Switzerland for loners.

Regarding the third sentence: There are over twenty journals of orthodontics but no journal of dental orthopaedics, and although I am firmly of the opinion that promoting the same methods of investigation and hoping for new results is exactly the definition of madness, I need to find a university that will employ me as an innovative staff member at an orthodontics clinic.

Regarding the fourth sentence: If none of the universities hire me, I'm probably checkmate. At least I have pointed out a flaw in the system.

What would be my goal on the issue of Covid-19 in society?

In December 2021, it was announced that emerging covid variants of concern [VOC] are driving the SARS-CoV-2 pandemic because, among other things, they have a higher affinity for the angiotensin converting enzyme 2 receptor [hACE2] and that it is important to use multiple models for a complete fitness characterisation of VOC (ULRICH, L., HALWE, N.J., TADDEO, A. *et al.* Enhanced fitness of SARS-CoV-2 variant of concern Alpha but not Beta. *Nature,* 2021). Angiotensin-converting enzyme-2 [ACE2] is the cellular entry point for the covid virus, where it replicates and causes damage. However, since ACE2 is also found in some bacteria (WIKIPEDIA, 2022), it is conceivable that the covid-19 viruses also multiply in bacteria of the oral cavity, which in turn are protected from antibodies in human tartar and can multiply there.

In relation to Covid-19 in society, I would like to clarify whether the virus hides in the calculus of patients without a fixed orthodontic retainer and/or with a fixed orthodontic retainer (**Fig. XVI**).

Figure XVI: My target question. Is calculus partly responsible for the long covid phenomenon?

First null hypothesis H0: Covid-19 cannot be found in the calculus of patients without a fixed orthodontic retainer.

Second null hypothesis H0: Covid-19 cannot be found in the calculus of patients with a fixed orthodontic retainer.

Will the University of Zurich help me answer my target question?

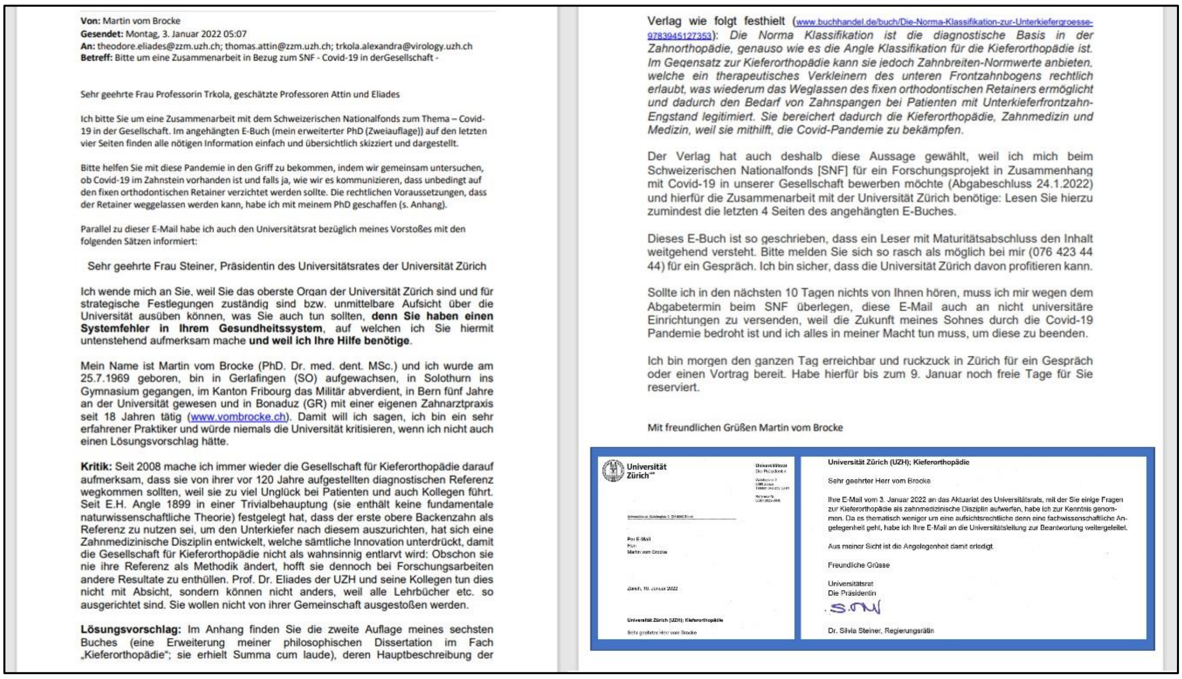
On 3 January 2022 - I emailed the 2nd edition of this e-book, to the President of the University Council of Zurich Dr Steiner as well as to Prof. Dr A. Trkola - Virology -, Prof. Dr T. Attin - Periodontology - and Prof. Dr T. Eliades - Orthodontics - with the request for cooperation in relation to the planned study (**Fig. XVII**).

Figure XVII: Study design. All the probands have to confirm that they do not feel they are suffering from any corona symptom before calculus removal. (a) shows the situation before and after removal of supra-gingival calculus in the mandibular anterior region in a patient not wearing a fixed orthodontic retainer. (b) shows the principle of "tartar collection" using scalers without blood contact. (c) shows the situation before and after removal of supra-gingival calculus in the mandibular anterior region in a patient with a fixed orthodontic retainer. (d) shows an excerpt from the homepage of the Institute of Medical Virology and Immunology at the University of Zurich as evidence of their field of activity.

The only thing that speaks against the support of the Swiss National Science Foundation is the fact that I am not employed at the University of Zurich. Perhaps a miracle will happen and an external scientific assistant for orthodontics will cede 50% of his employment points to me for one year in my favour. Or the university creates an office for dental orthopaedics. Or the University of Zurich places me in some interdisciplinary faculty so that I am a coordinator under the health system. Please, dear University of Zurich and SNF, help me so that I can tell my son that everything will be fine.

Which e-mail did I send to University of Zurich for this purpose?

Figure XVIII records my efforts of 3 January 2022, when I contacted the University Council by email, and its reply of 10 January 2022, in which its President, Dr Steiner, writes that she forwarded my questions on orthodontics to the university management because it was a rather specialised scientific matter (**Figure XVII**).



Von: Martin vom Brocke
Gesendet: Montag, 3. Januar 2022 05:07
An: theodore.eliades@zzm.uzh.ch; thomas.attin@zzm.uzh.ch; trkola.alexandra@virology.uzh.ch
Betreff: Bitte um eine Zusammenarbeit in Bezug zum SNF - Covid-19 in derGesellschaft -

Sehr geehrte Frau Professorin Trkola, geschätzte Professoren Attin und Eliades

Ich bitte Sie um eine Zusammenarbeit mit dem Schweizerischen Nationalfonds zum Thema – Covid-19 in der Gesellschaft. Im angehängten E-Buch (mein erweiterter PhD (Zweiauflage)) auf den letzten vier Seiten finden alle nötigen Information einfach und übersichtlich skizziert und dargestellt.

Bitte helfen Sie mit diese Pandemie in den Griff zu bekommen, indem wir gemeinsam untersuchen, ob Covid-19 im Zahnstein vorhanden ist und falls ja, wie wir es kommunizieren, dass unbedingt auf den fixen orthodontischen Retainer verzichtet werden sollte. Die rechtlichen Voraussetzungen, dass der Retainer weggelassen werden kann, habe ich mit meinem PhD geschaffen (s. Anhang).

Parallel zu dieser E-Mail habe ich auch den Universitätsrat bezüglich meines Vorstoßes mit den folgenden Sätzen informiert:

Sehr geehrte Frau Steiner, Präsidentin des Universitätsrates der Universität Zürich

Ich wende mich an Sie, weil Sie das oberste Organ der Universität Zürich sind und für strategische Festlegungen zuständig sind bzw. unmittelbare Aufsicht über die Universität ausüben können, was Sie auch tun sollten, **denn Sie haben einen Systemfehler in Ihrem Gesundheitssystem**, auf welchen ich Sie hiermit untenstehend aufmerksam mache **und weil ich Ihre Hilfe benötige**.

Mein Name ist Martin vom Brocke (PhD. Dr. med. dent. MSc.) und ich wurde am 25.7.1969 geboren, bin in Gerlafingen (SO) aufgewachsen, in Solothurn ins Gymnasium gegangen, im Kanton Fribourg das Militär abverdient, in Bern fünf Jahre an der Universität gewesen und in Bonaduz (GR) mit einer eigenen Zahnarztpraxis seit 18 Jahren tätig (www.vombrocke.ch). Damit will ich sagen, ich bin ein sehr erfahrener Praktiker und würde niemals die Universität kritisieren, wenn ich nicht auch einen Lösungsvorschlag hätte.

Kritik: Seit 2008 mache ich immer wieder die Gesellschaft für Kieferorthopädie darauf aufmerksam, dass sie von ihrer vor 120 Jahre aufgestellten diagnostischen Referenz wegkommen sollten, weil sie zu viel Unglück bei Patienten und auch Kollegen führt. Seit E.H. Angle 1899 in einer Trivialbehauptung (sie enthält keine fundamentale naturwissenschaftliche Theorie) festgelegt hat, dass der erste obere Backenzahn als Referenz zu nutzen sei, um den Unterkiefer nach diesem auszurichten, hat sich eine Zahnmedizinische Disziplin entwickelt, welche sämtliche Innovation unterdrückt, damit die Gesellschaft für Kieferorthopädie nicht als wahnsinnig entlarvt wird: Obschon sie nie ihre Referenz als Methodik ändert, hofft sie dennoch bei Forschungsarbeiten andere Resultate zu enthüllen. Prof. Dr. Eliades der UZH und seine Kollegen tun dies nicht mit Absicht, sondern können nicht anders, weil alle Lehrbücher etc. so ausgerichtet sind. Sie wollen nicht von ihrer Gemeinschaft ausgestoßen werden.

Lösungsvorschlag: Im Anhang finden Sie die zweite Auflage meines sechsten Buches (eine Erweiterung meiner philosophischen Dissertation im Fach „Kieferorthopädie"; sie erhielt Summa cum laude), deren Hauptbeschreibung der Verlag wie folgt festhielt (www.buchhandel.de/buch/Die-Norma-Klassifikation-zur-Unterkiefergroesse-9783945127353): *Die Norma Klassifikation ist die diagnostische Basis in der Zahnorthopädie, genauso wie es die Angle Klassifikation für die Kieferorthopädie ist. Im Gegensatz zur Kieferorthopädie kann sie jedoch Zahnbreiten-Normwerte anbieten, welche ein therapeutisches Verkleinern des unteren Frontzahnbogens rechtlich erlaubt, was wiederum das Weglassen des fixen orthodontischen Retainers ermöglicht und dadurch den Bedarf von Zahnspangen bei Patienten mit Unterkieferfrontzahn-Engstand legitimiert. Sie bereichert dadurch die Kieferorthopädie, Zahnmedizin und Medizin, weil sie mithilft, die Covid-Pandemie zu bekämpfen.*

Der Verlag hat auch deshalb diese Aussage gewählt, weil ich mich beim Schweizerischen Nationalfonds [SNF] für ein Forschungsprojekt in Zusammenhang mit Covid-19 in unserer Gesellschaft bewerben möchte (Abgabeschluss 24.1.2022) und hierfür die Zusammenarbeit mit der Universität Zürich benötige: Lesen Sie hierzu zumindest die letzten 4 Seiten des angehängten E-Buches.

Dieses E-Buch ist so geschrieben, dass ein Leser mit Maturitätsabschluss den Inhalt weitgehend versteht. Bitte melden Sie sich so rasch als möglich bei mir (076 423 44 44) für ein Gespräch. Ich bin sicher, dass die Universität Zürich davon profitieren kann.

Sollte ich in den nächsten 10 Tagen nichts von Ihnen hören, muss ich mir wegen dem Abgabetermin beim SNF überlegen, diese E-Mail auch an nicht universitäre Einrichtungen zu versenden, weil die Zukunft meines Sohnes durch die Covid-19 Pandemie bedroht ist und ich alles in meiner Macht tun muss, um diese zu beenden.

Ich bin morgen den ganzen Tag erreichbar und ruckzuck in Zürich für ein Gespräch oder einen Vortrag bereit. Habe hierfür bis zum 9. Januar noch freie Tage für Sie reserviert.

Mit freundlichen Grüßen Martin vom Brocke

Universität Zürich

Per E-Mail
Herr
Martin vom Brocke

Zürich, 10. Januar 2022

Universität Zürich (UZH); Kieferorthopädie

Sehr geehrter Herr vom Brocke

Ihre E-Mail vom 3. Januar 2022 an das Aktuariat des Universitätsrats, mit der Sie einige Fragen zur Kieferorthopädie als zahnmedizinische Disziplin aufwerfen, habe ich zur Kenntnis genommen. Da es thematisch weniger um eine aufsichtsrechtliche denn eine fachwissenschaftliche Angelegenheit geht, habe ich Ihre E-Mail an die Universitätsleitung zur Beantwortung weitergeleitet.

Aus meiner Sicht ist die Angelegenheit damit erledigt.

Freundliche Grüsse

Universitätsrat
Die Präsidentin

Dr. Silvia Steiner, Regierungsrätin

Figure XVII: My e-mail correspondence with the Zurich University Council.

Because I have not received an answer from the university management by 19.01.2022, although it is easy to write an answer - e.g. we ask for a little patience - I assume that this time my "solo effort" will also be considered unimportant. The last twelve years have shown me that it is very easy to exclude someone by remaining dead silent. After all, as a university employee you also receive your salary if you can only check old methods.

I therefore decided to change my strategy and ask the SNF to support me in setting up an online campus learning platform "DENTAL ORTHOPAEDICS". After all, if the discipline of dental orthopaedics becomes known, the retainer problem will also be gone. Historically, dental orthopaedics has existed since Aulus Cornelius Celsus (* ca. 25 BC; † ca. 50 AD), who recommended milk tooth extraction to control the eruption of the permanent teeth. In 1906, E.H. Angle snatched dental orthopaedics away from dentists and I am bringing it back so that young colleagues can be trained in this discipline again.

How could an online campus learning platform look like?

In order for a "newcomer" to dental orthopaedics to be able to develop a well-founded understanding, it is of decisive importance for the platform user to know that the references and the therapy goal that are binding for dental orthopaedics did not arise from an arbitrary invention or trivial assertion, as was the case in orthodontics by ANGLE in 1899 but are the result of 12 years of basic research that led to the structural theory of gravitation. In principle, this theory states that humans are at the top of the food chain because their anatomical structures are positioned according to functions that are particularly well suited to gravity (**Fig. XVIII**).

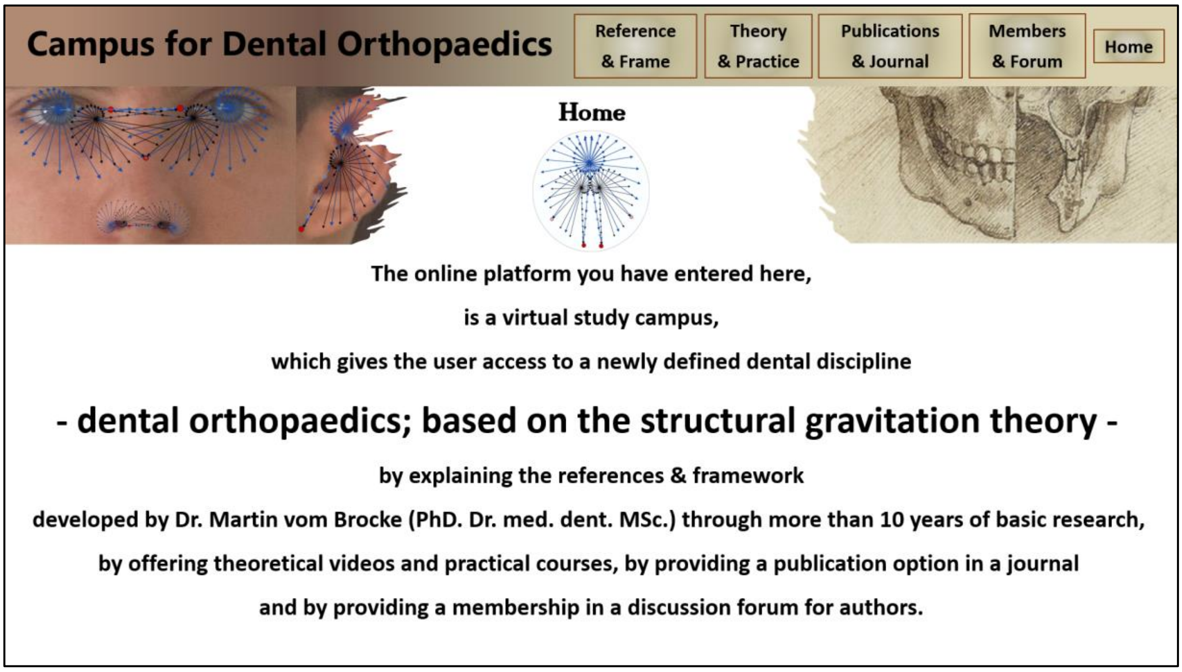


Figure XVIII: Online campus learning platform. With the ζ4-function as the basis of two 24-part logarithmic spirals, which are linked in the Hausdorff dimension $D = \ln 2/\ln 3$ as a struction spiral, it can be illustrated how in each case two connected functions build up a structural facial unit (e.g. a circle with centre in the navel and the second centre in the mouth; or the eyes in relation to the lacrimal canal; or the auricle in relation to the auditory canal; or the nostril in relation to the nasal entrance). For example, the struction spiral can be used to draw in the morphological maxilla - see page 33 - to divide mandibular sizes and to define the occlusion of the first premolars as the most appropriate - most neutral - therapeutic target.

Could the Swiss National Foundation perhaps help me after all?

The online campus learning platform requires many things, such as short video films, which the user can watch for a small fee, in order to learn the basics of representative mathematics, diagnostics and therapy. My first dissertation (ISBN 978-3-945127-06-3) showed that learning in the form of question and video answer - problem-based-learning - produces the most efficient memory effect. At a rough estimate, about 1000 professional videos would have to be produced at a cost of about 1 million Swiss francs. Because the online platform is accessible worldwide, it will be a permanent source of income and worth the investment. In addition, about 0.5 million Swiss francs would be needed to develop a facial recognition app with the struction spiral (patent costs, production costs, data pool acquisition, etc.), so that an ethically more justifiable aid than the cephalometric device is available, with which syndromes can be distinguished from natural jaw sizes, because different diagnoses often also require different therapies (**Fig. XIX**).

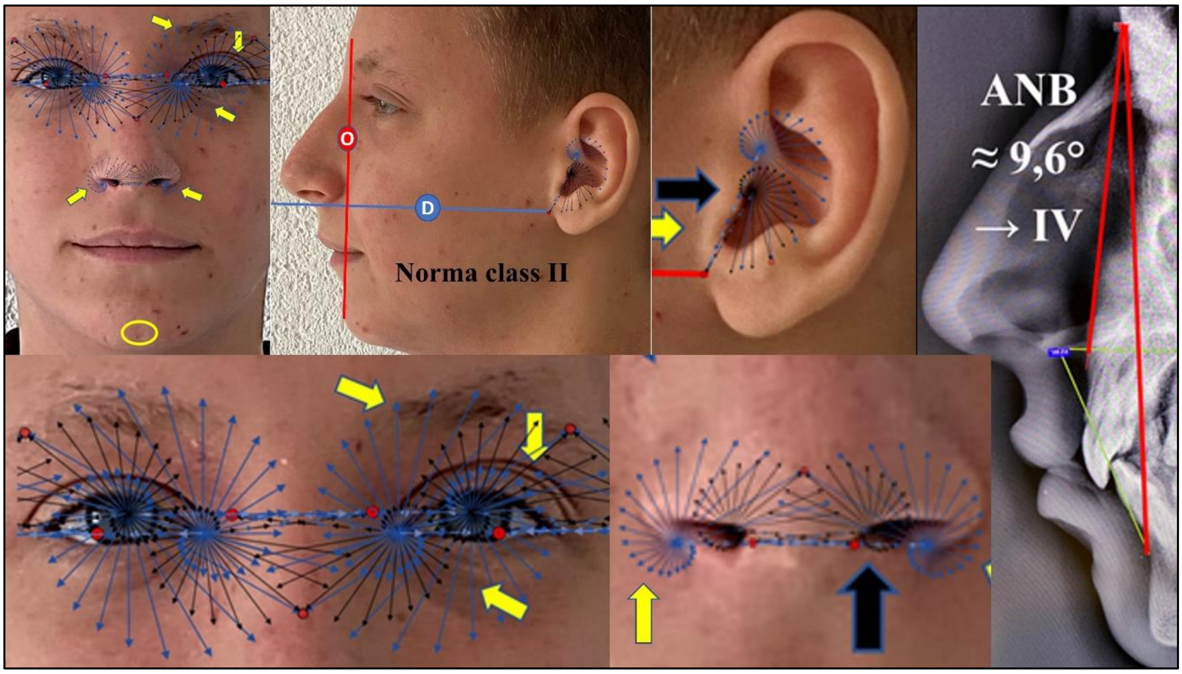
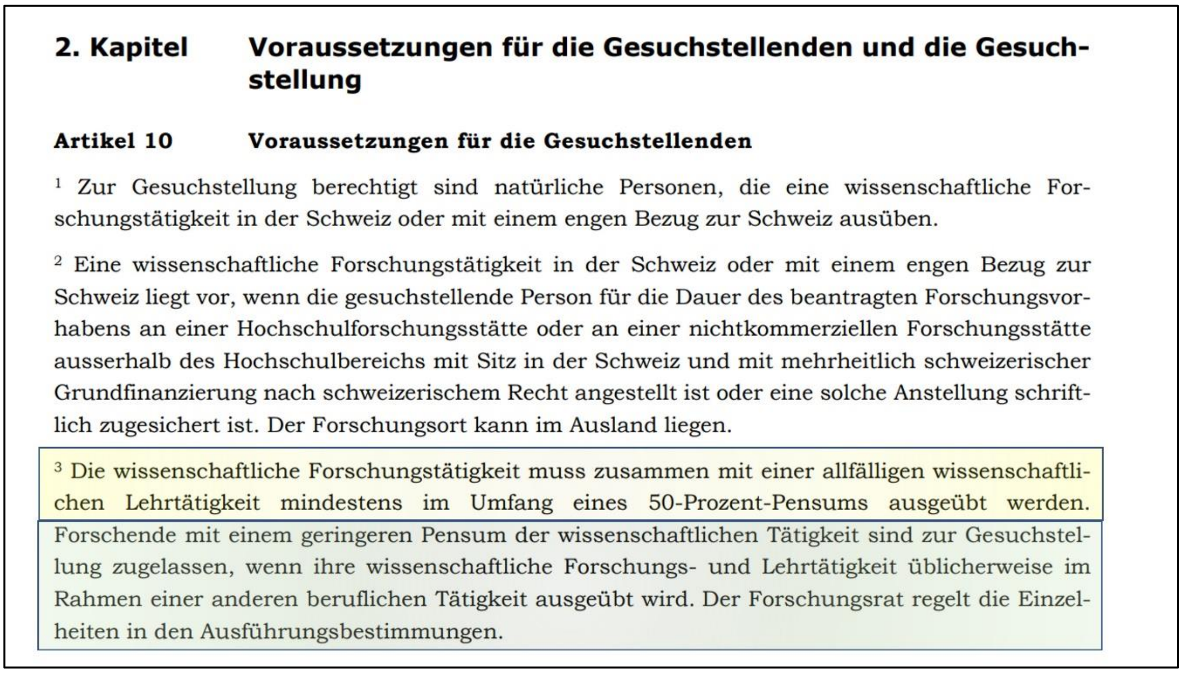


Figure XIX: A face app for syndrome detection. The illustration shows a 14-year-old patient suffering from enamel dentin formation disorder and conductive hearing loss. The overlay with the struction spiral also reveals: too small nostrils, lower auricles and lower jaw sides as well as an underdevelopment of the eyebrow and eyelid on the left. The teleradiograph taken proves IV eligibility with an ANB angle, although it does not offer any indication of cause, which would be decisive for the treatment plan.

All in all, I estimate that the SNSF would have to help me with about 3 million francs.

Who calls the shots at the Swiss National Foundation [SNF]?

While thoroughly reading through all the requirements that must be fulfilled for me as a scientist to have a chance of receiving financial support from the SNF, at some point I landed on the SNF funding regulations, which in the version of 1.1.2016 in Chapter 2, Article 10, Paragraph 3 state *"... teaching activity at least to the extent of a 50-percent stint ...". " ... teaching activity usually in the context of another activity ... The Research Council shall regulate the details in the implementing provisions."* (**Fig. XX**).



2. Kapitel Voraussetzungen für die Gesuchstellenden und die Gesuchstellung

Artikel 10 Voraussetzungen für die Gesuchstellenden

1 Zur Gesuchstellung berechtigt sind natürliche Personen, die eine wissenschaftliche Forschungstätigkeit in der Schweiz oder mit einem engen Bezug zur Schweiz ausüben.

2 Eine wissenschaftliche Forschungstätigkeit in der Schweiz oder mit einem engen Bezug zur Schweiz liegt vor, wenn die gesuchstellende Person für die Dauer des beantragten Forschungsvorhabens an einer Hochschulforschungsstätte oder an einer nichtkommerziellen Forschungsstätte ausserhalb des Hochschulbereichs mit Sitz in der Schweiz und mit mehrheitlich schweizerischer Grundfinanzierung nach schweizerischem Recht angestellt ist oder eine solche Anstellung schriftlich zugesichert ist. Der Forschungsort kann im Ausland liegen.

3 Die wissenschaftliche Forschungstätigkeit muss zusammen mit einer allfälligen wissenschaftlichen Lehrtätigkeit mindestens im Umfang eines 50-Prozent-Pensums ausgeübt werden. Forschende mit einem geringeren Pensum der wissenschaftlichen Tätigkeit sind zur Gesuchstellung zugelassen, wenn ihre wissenschaftliche Forschungs- und Lehrtätigkeit üblicherweise im Rahmen einer anderen beruflichen Tätigkeit ausgeübt wird. Der Forschungsrat regelt die Einzelheiten in den Ausführungsbestimmungen.

Figure XX: An abstract of the SNF's funding regulations.

As the owner of an SSO training practice for general dentistry, from 2013 to 2018 I repeatedly drew the attention of the SSO - Swiss Dental Association - to the fact that the orthodontists were blocking innovative research by "keeping quiet" in order to protect their "cartel". "Cartel" also because they are practically the only dentists who have oneshot cephalometric X-ray apparatus and can thus carry out an IV assessment. No one from the SSO board ever replied to me. In 2018, I started my three-year science studies in Austria (Krems) because I was able to find a professor for biostatistics (Prof. W. Frank) there as a supervisor for a PhD.

The last sentence on the SNSF guidelines and regulations reads: "If you are unclear, we recommend that you contact the SNSF office".

I did this because of the unclear equality on research funding.

How does the SNSF respond to the lack of clarity regarding equal funding?

On 21 January 2022, I sent the 2nd extended edition of this book (ISBN: 978-3-945127-35-3) to the SNF. In doing so, I asked the SNF to check whether I was entitled to apply, because point 1.2 of the application regulations (Fig. XX) was not entirely clear to me. On 8 February 2022, the director of the SNF (Ms. Kalt) replied with the central statement for the understanding of point 1.2 AR: ".... employed by the SNF research institution authorised to submit applications ...." (**Fig. XXI**).

> Erlauben Sie uns, dazu folgende Differenzierung zu erläutern, die für das Verständnis von Ziff. 1.2 AR zentral ist: Für die Gesuchstellung beim SNF ist vorausgesetzt, dass Forschende zu einem Pensum von mindestens 50% an einer beim SNF antragsberechtigten Forschungsstätte angestellt sind. Vom Beschäftigungsgrad zu unterscheiden ist der Anteil an wissenschaftlicher Tätigkeit (in Art. 10 Abs. 3 des Beitragsreglements definiert als wissenschaftliche Forschungstätigkeit zusammen mit einer allfälligen wissenschaftlichen Lehrtätigkeit). Bei klinisch tätigen Forschenden, Angestellten von Archiven und Museen mit Forschungszweck sowie Angestellten in Gesundheitsberufen darf der Anteil der wissenschaftlichen Tätigkeit unter 50% (bezogen auf 100% Beschäftigungsgrad) liegen. Als Beispiel ist etwa ein klinisch tätiger Forscher anzuführen, der zu 100% an einer beim SNF antragsberechtigten Gesundheitsinstitution angestellt ist. Wäre er nur im Umfang von 30% wissenschaftlich tätig, würde er gestützt auf Ziff. 1.2 AR dennoch zur Gesuchstellung zugelassen. Wäre er hingegen nur zu 40% an der antragsberechtigten Gesundheitsinstitution angestellt, würde wegen der 50%-Hürde gemäss Ziff. 1.2 (1. Satz) AR eine Gesuchstellung beim SNF zum Vornherein ausser Betracht fallen.
> Vor diesem Hintergrund ist Ihre Antragsberechtigung beim SNF zu verneinen.
>
> Wir bedauern, Ihnen keinen besseren Bescheid geben zu können, und hoffen auf Ihr Verständnis.
>
> Freundliche Grüsse
> Angelika Kalt
>
> Angelika Kalt
> Direktorin
> Schweizerischer Nationalfonds

Figure XXI: Explanation of point 1.2 AR by the Director Ms Angelika Kalt.

Ms Kalt's answer proves that a practising dentist – even with an SSO continuing education certificate and an SSO continuing education practice – has no possibility of receiving equal support for scientific activity. The Swiss National Foundation should therefore correctly call itself the Swiss "Fund for eligible persons", because the word "national" refers to all Swiss institutions and not to a few – undeclared – institutions. The SNF only supports scientists from research institutions that correspond to the interests of the SNF and not as they declare on the opening page of their homepage: "We invest in researchers and their ideas" (**see Fig. XV**). Is the omission of such information on the use of national institutions really in conformity with the law? Personally, I feel betrayed and left alone, because even the Swiss Dental Association SSO, according to its vice-president (Dr Senn), cannot help me directly.

Why can't the Dental Society SSO (Dr. Senn) help me directly?

With an email congratulating me on my PhD work, Dr Senn also draws my attention to four facts which hardly surprise me (**Fig. XXII**).

Sehr geehrter Herr Kollege vom Brocke

Cc: Simon Gassmann; Haesler Jean-Philippe
Gesendet: Sonntag, 6. Februar 2022 17:07

Vielen Dank für die Zusendung Ihrer erfolgreichen PhD-Arbeit, zu der ich Sie ganz herzlich beglückwünsche. Ich habe Ihre Arbeit durchgesehen, wenn auch als Nichtkieferorthopäde nicht bis in alle Details, und ich zolle Ihnen meinen vollen Respekt für Ihre langjährige und aufwändige Auseinandersetzung mit einer interessanten und offenbar kontrovers diskutierten Thematik. Bei den von Ihnen aufgeworfenen Fragen und deren möglicher Antworten handelt es sich um sehr spezifische fachliche Aspekte, deren Wertung und Berücksichtigung im klinischen Alltag die Kenntnisse und Kompetenzen der SSO weit übersteigen; dafür sind die akademischen Institutionen sowie die Fachgesellschaften zuständig. Ich empfehle Ihnen, mit diesen Instanzen einen gegenseitig kollegialen und wohlwollenden fachlichen Austausch anzustreben, wie das im Wissenschaftsbetrieb üblich ist. Im Übrigen gehe ich davon aus, dass die Ihnen ein „summa cum laude" vergebende Universität auch Unterstützung zur Implementierung Ihrer Resultate in ihren Ausbildungs- und Forschungsbereich gewähren sollte.
In diesem Sinne bedaure ich, dass der SSO-ZV Ihnen nicht direkt weiterhelfen kann, ich wünsche Ihnen aber auf Ihrem wissenschaftlichen Weg weiterhin alles Gute!

Freundliche kollegiale Grüsse
Christoph Senn

Dr. med. dent. Christoph Senn
Vizepräsident SSO
T 061 381 80 80
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Figure XXII: E-mail congratulations on my PhD work by the SSO.

The SSO has no idea what orthodontists actually do and also wants to stay out of the matter. The SSO, I suspect here, capitulated on orthodontics many years ago. The SSO assumes that a dissertation with summa cum laude also changes the doctrinal opinion and *assumes that I have an academic career*. The SSO apparently does not know that professors of orthodontics are in principle only obliged to adjust the teaching opinion if a research result has also been published in a journal of orthodontics, and since my PhD results can only be published in a journal of orthodontics - which does not exist - these professors do not have to share the result. If there was a chair of dental orthopaedics, I would have a scientific career and God is my witness, I would accept this chair because I belong in a university and not in a dental practice. I have been very unhappy and sad for many years that I have to work in a practice because my intellectual potential is much more far-reaching. If the University of Zurich does not have the courage for a new professorship, a lot of knowledge will be lost, because the Danube Private University in Krems founded in 2009 is still too young for a new professorship.

Why a new teaching chair instead of more money for orthodontists?

On 14. 2. 2022, the Dean of the Faculty of Medicine of the University of Zurich wrote to me to reply on behalf of the President of the University Council (**Fig. XXIII**).

He writes that the university prefers to spend its scarce resources on highly specialised specialists who stand a chance of winning a prize, rather than on practitioners with an interesting research approach.

Which raises the questions: What awards can an orthodontist win if he can only publish in journals with a maximum impact factor of 3? Did he not send a copy of the letter to the President because he is aware that society and the economy depend on innovation and not on awards and that the President expects contemporary answers (**Fig. XXIII b**)?

The orthodontists strike me as thirst-driven desert wanderers whom Mr. E.H. ANGLE had forbidden to leave his invented way of finding water in 1899, without giving any reason (**Fig. XXIII c**).

The dean had not contacted me but the orthodontists and confirmed in his letter that their aim was to win prizes but apparently not to train dentists as required by the state exams (Diploma). So why do they have a teaching chair? This one is probably defective. So a new chair is needed so that we dentists can also learn how to shift teeth. Please, dear University Council, help us dentists and patients in Switzerland.