MASTER THESIS

Interdisciplinary Treatment of TMJ Disorder In Conjunction With Orthopedic 3D Scan

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Interdisciplinary Treatment of TMJ Disorder In Conjunction With Orthopedic 3D Scan

ABSTRACT

Objective

Objective of this investigation is to show the direct relation between temporomandibular malposition and a spinal malposition, and to demonstrate the possibilities to correct spinal malpositions by means of occlusal corrections.

The long time assumed relation between the spine and the temporomandibular system is to be documented and proved with the aid of a reproducible measuring technique by means of a newly developed interdiciplinary examination method.

Object

A population of 60 patients of different age groups was examined. All patients showed typical pain syndromes as well as a measurable afunctional articulation of habitual occlusion and ideal jaw position (physiological position of the jaw).

Method

All patients underwent a clincial functional analysis at the beginning of the investigation as well as a basic orthopedic examination. Following these basic examinations the population was examined by means of an instrumental functional analysis. The temporomandibular system was measured with the condylographic device of the company Gamma, Austria. The static scan of the spine was done with the 3D device "formetric" of the company DIers International, Germany. With the "formetric" unit of Diers it

was measured how occlusal corrections were influencing the dislocation of the spine.

Results

From all scanned data taken by the 3D scan system, the most relevant values for this investigation, the trunk imbalance and the deviation in rotation, were evaluated. The trunk imbalance is measuring the lateral inclination of the spine in relation to the sacrum plane in millimeter. The limit value of a healthy person is defined as 7,5 mm. The deviation in rotation is measuring the deviation of the vertebra in their rotation. The limit value here is 5 degrees. The statistical evaluation of the trunk imbalance proved that 71,7% of the subjects had significant improvements of their spinal position when the occlusion was corrected. The average value of the improvement was 3 mm, thus considered to be a highly significant difference ($p<0,001$) between scan with and without splint. For the rotation a significant improvement of the spine position could be determined in 68,3% of the subjects. The mean value of the improvement here was 2,06 degrees, thus considered to be a statistically highly significant difference ($p<0,001$) as well.

Keywords: TMJ disorder, Musculoskeletal system, 3D Scan of Spine, Condylography, Interdisciplinary Therapy

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PREFACE

Already in 1985 I came into contact with the field of functional dentistry when I attended my first course with Prof. Dr. Rudolf Slavicek in cephalometric radiography. From now on and ever since I started my own practise in 1986, functional dentistry was an integral part of my daily activities. The postgraduate course "Dental Sciences (MSc)" inspired me to intensify my interdisciplinary efforts. From the knowledge which I was able to acquire in my postgraduate courses arose the desire to develop a scientific and reproducible method in TMD treatment, in order to complement the present form of interdisciplinary therapy, which so far mostly relies on subjective, personal judgement and experience.

Based on my knowlege and insights from the national and international postgraduate courses at the Donau Universität Krems, in cooperation with the Kanagawa Dental College, Yokosuka, Japan and the Tufts University School Of Dental Medicine, Boston, USA I developed together with orthopedists in 2003 a diagnosis and therapy method, which allows to scientifically measure and document the interrelation between the craniomandibular system and the static of the spine.

Initiation as well as carrying out of this research was only possible through the knowledge which I acquired in many courses with Prof. Dr. Slavicek and the insights and inspirations in my national and international postgraduate courses. First and foremost I would like to deeply and respectfully thank Univ.-Prof. MR. Dr. Slavicek for his personal guidance. Prof. Dr. Slavicek was and continues to be a role model for me and drive for my professional career. I would like to thank Prof. Dr. Meta for his inspirations in the interdisciplinary topic, which increased and extended my awareness beyond the dental field of activity. I would like to respectfully thank Prof. Dr. Sato for the extraordinary insights and scientific knowledge

he shared with me and especially for his documentation and presentations he generously provided me with and which I have since been able to integrate in many of my own lectures. Furthermore I would like to thank Mr. Horn from Messrs Diers for his help in translating and correcting the orthopedic terminology, for his advice and for providing the necessary documentation in the orthopedic field.

It remains to be hoped that the interdiciplinary diagnosis and therapy of TMD can be established to a generally recognized treatment standard for the benefit of the patients. I truly hope that this research is a further contribution to this important field of activity.

Cologne, April 2007

Dieter Ritter

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1. INTRODUCTION

1.1 Dental Aspects

Although the classical school medicine continues to separate the individual fields of medicine, the interdiciplinary character has gained much importance for the past few years.

Rocabado (15) had discovered in 1983 already the connection of afunctional occlusion and the ventral displacement of the head and the spinal position. Subsequently numerous scientific evidences have been found about the direct connection of spine and madibular occlusion, in physiotherapy and orthopedics as well as in dentistry. Lotzmann (12) could determine that the ventral and retroflexion is caused by forward and backward positioning of the mandibula, and that the lateral turn of the head is caused by a loss of the supporting area on one side. Kobayashi (10) and Fink (5) proved that imitated occlusal dysfunctions directly affect the body movement of the cervical spine as well as the pelvis. Utz (17) proved with the aid of differently sized aluminum oxide particles a human perception limit of 1/10 mm.

Leuschner (11), Fink (6) (4), Danner (1) could prove as well a direct connection between occlusion and static of spine. Ridder (14) investigated from an orthopedic point of view the therapy of cervical spine problems by means of splints. Lotzmann (13) demonstrated by means of a special measuring plate the relation between the occlusion and the static of the spine. Fink (3) demonstrated that even TMJ patients without typical syndromes to a high degree showed muscle tensions in the cervical spine.

The collaboration of physiotherapy and dentistry was the beginning of the interdiciplinary trend. The effects of the occlusion to various parts of the

spine, cervical and thoracal spine and pelvic position, was the topic in diagnostics and therapy. By means of physiotherapeutic manual functional analysis methods the head position in lateral inclination and reclination and proclination in conjunction with the occlusion was investigated and used in therapy (12). Lately these manual methods have been backed up by videographic recordings and electromyographic control mechanisms. (11,13). In the same way a diagnosis and control method arose which investigates the interdependence of rotation and flexion of the pelvis and the mandibular occlusal position.

For the past few years orthopedics as well has started to open up to these ideas as it became more and more obvious that many orthopedic problems directly went along with temporomandibular symptoms. By now modern technique increasingly allows to instrumentally constitute statics and dynamics of the spine. The Kistler measuring template form for computer aided posturography (13) which has been used for years has lately been complemented by two new units. The 3D-Scan unit "Sonosens" is measuring the statics and mobility of the spine by means of ultrasonic sensors before and after occlusal adjustments, e. g. by means of splints. The 3D-Scan system "formetric" is measuring the statics of the spine by means of a light-optical non-invasive technique. This method quickly allows reproducible records and measuring values of flexion and rotation of the complete spine in varying occlusal situations.

An exact documentation is possible with these instrumental analytic methods, making measured values and outlines relocatable and allowing them to be used in diagnosis, therapy and therapy check-up of TMJ disorders.

Regardless numerous evidence based studies the interdisciplinary diagnosis and therapy of TMJ disorders continues to be discussed

controversially. Nevertheless very often an interrelation of spine statics and TMJ disorders is detectable in both, scientific studies as well as in practice. The present investigation aims to show the interrelation with orthopedics by means of an instrumental method. The statics of the spine of 60 subjects with TMJ disorder were examined before and after occlusal correction with the 3D scan system "formetric".

1.2. Orthopedic Aspects

1.2.1. Anatomic Parameters

At the beginning of the discussion of orthopedic points of view it is necessary to explain the basic parameters which are clinically relevant for the evaluation of three dimensional measurement.

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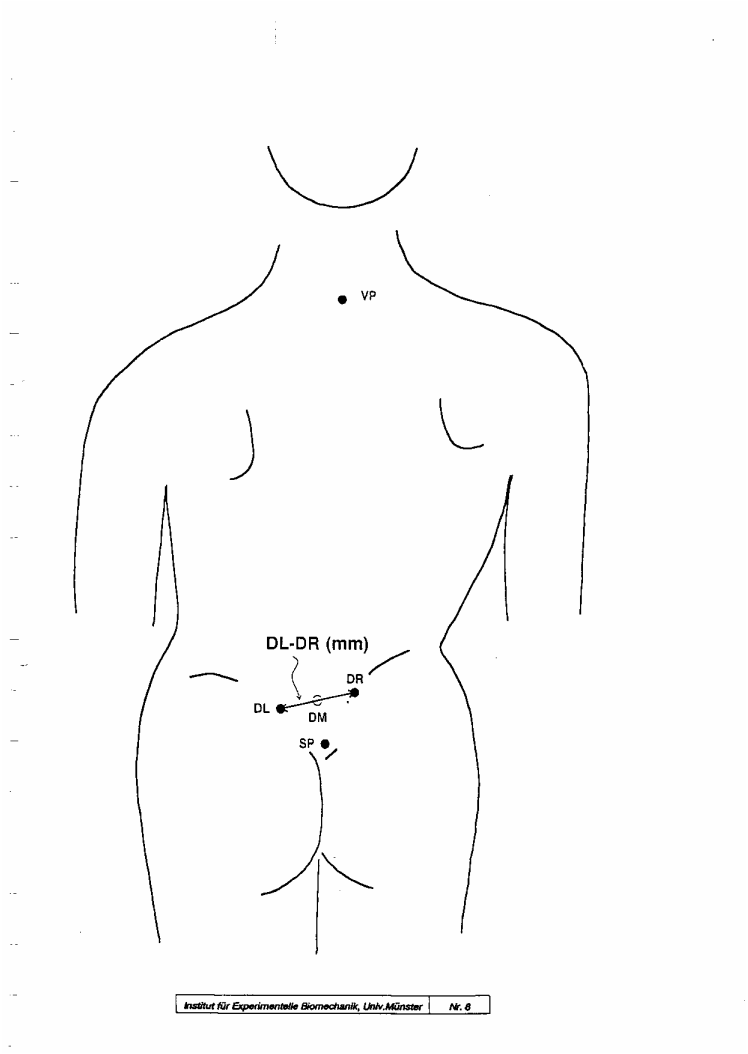

Ill. 1 Back View With Measuring Points VP, SP, DL, DR, DM

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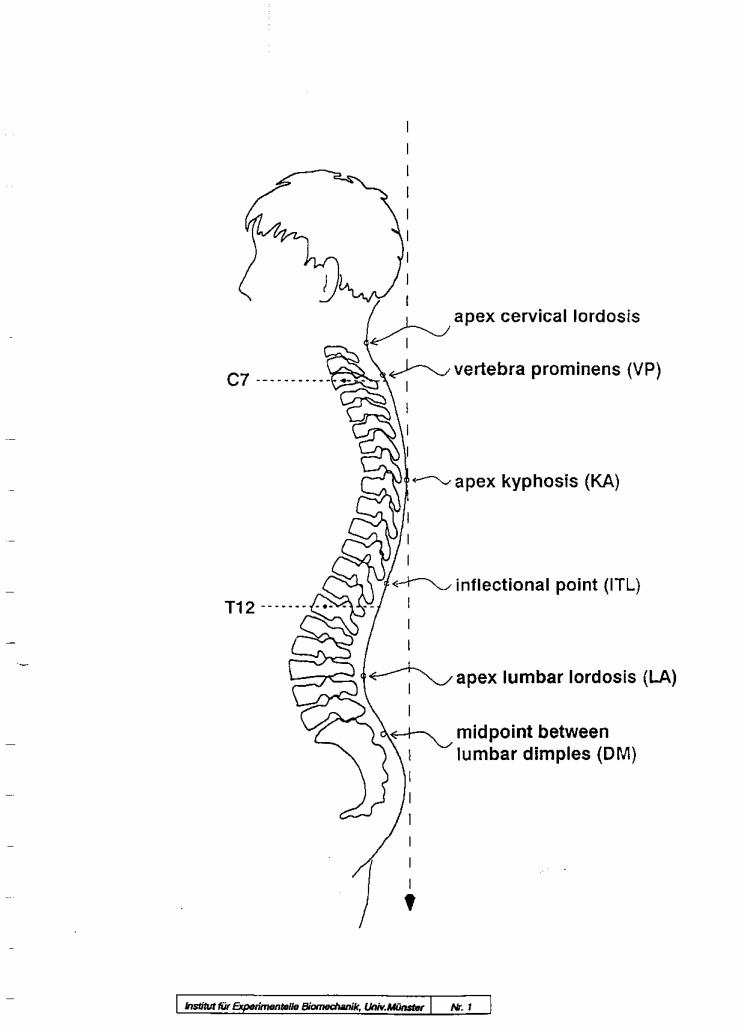

Ill. 2 Positional Relation Of Anatomic Landmarks In The Sagittal View

Anatomic Parameters

VP = Vertebra Prominens

SP = Sacrum-Point (Beginning of the Rima ani)

DL = Lumbar Dimple left SIPS

DR = Lumbar Dimple right, SIPS

DM = Midpoint Dimple

Inflectional Point ITL

The thoracic-lumbar inflectional point (ITL in the lateral projection) is the maximum lateral tilt beneath the kyphotic apex (see inclination curve).

Kyphotic angle ICT-ITL (max)

This is the maximum kyphotic angle, measured between the cervical-thoracic inflectional point ICT near the VP and the thoracic-lumbar inflectional point ITL. The accessory tangents are marked as broken lines in the lateral projection.

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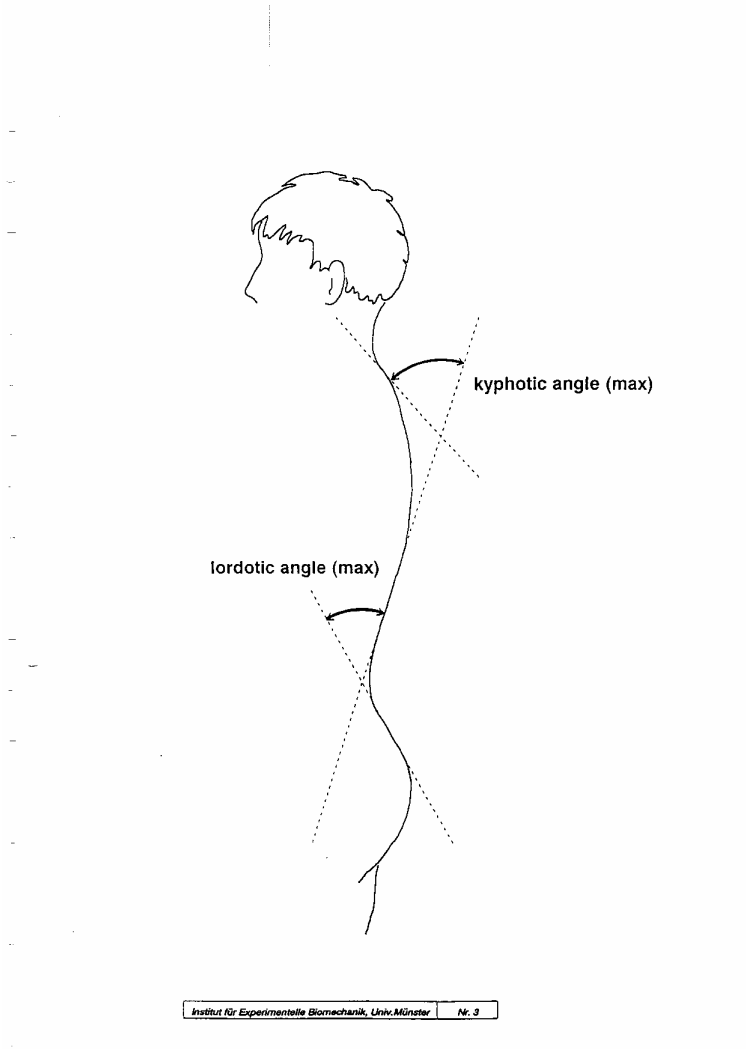


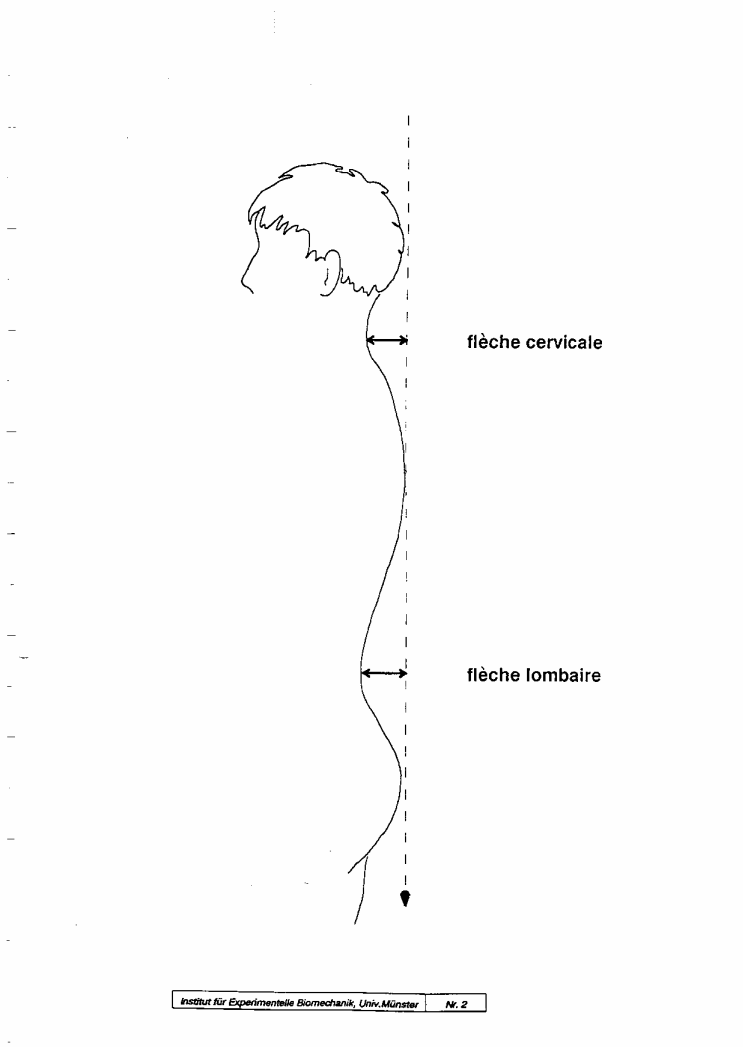
Ill. 3 Definition Of Maximum Kyphotic And Lordotic Angles

Lordotic angles

These angles are defined analogous to the corresponding kyphotic angles, however the fixed landmark VP is being replaced by DM. The maximum lordotic angle is defined through the thoracic-lumbar inflectional point ITL and the lumbo-sacral inflectional point ILS near the DM. The position of the different points are stated in millimeters (measured from VP).

Flèche cervicale / Flèche lombaire

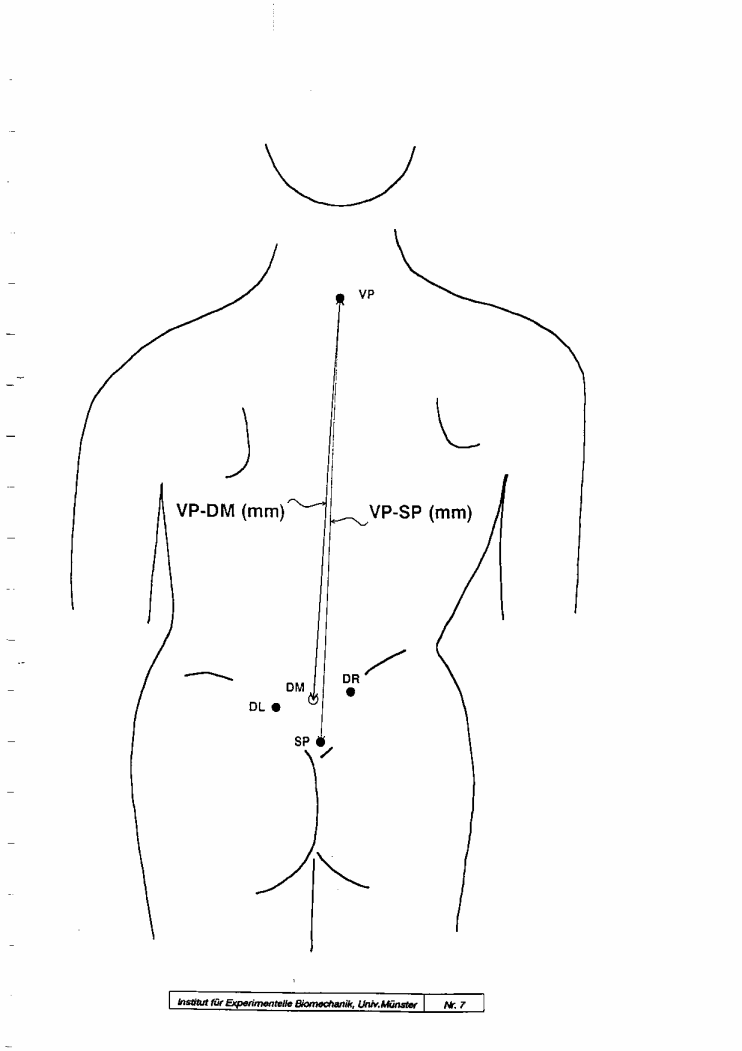
The flèche parameters are calculated from the sagittal view acc. to the definition of Stagnara (16). Ideally the distances of the body surfaces of the vertical tangents are cervically and lumbally equal.



Ill. 4 Flèche Cervicale And Flèche Lombaire Acc. To Stagnara

Trunk length VP-DM

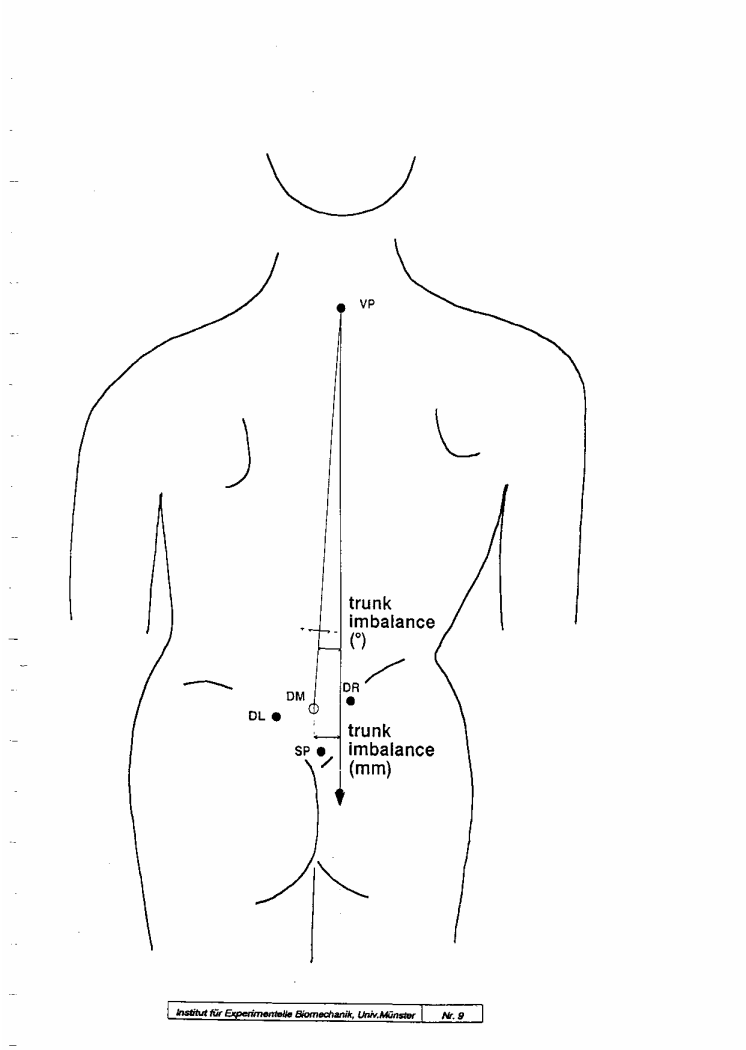
The trunk length is defined as spatial distance VP-DM.



Ill. 5 Two Measures For Trunk Length

Trunk imbalance VP-DM:

The trunk imbalance, measured in millimeters is defined as the lateral distance of VP of the midpoint between the lumbar dimples.



Ill. 6 Definition Of Trunk Imbalance

Pelvis tilt DL-DR:

The pelvis tilt is defined by a difference in level of the lumbar dimples, referring to the horizontal level.

Pelvic torsion DL-DR:

The pelvic torsion is determined by the mutual torsion of both lumbar dimples with relation to the normal plane.

Lateral deviation (rms):

This parameter describes the mean square deviation (rms) of the spinal midline, measured from the line VP-DM in the frontal plane.

Lateral deviation (max):

This parameter describes the maximum deviation of the spinal midline, measured from the line VP-DM, i. e. the value at the apex in the frontal plane.

Surface rotation (rms):

This parameter describes the mean square value of the surface rotation of the symmetry line.

Surface rotation (max):

This parameter describes the maximum surface rotation at the apex.

1.2.2. 3D-Parameters

Due to its original purpose the device was developed for, the formetric system is especially interesting for the investigation of scoliosis and for the differentiation of scoliosis and scoliotic malposition. In 2001 Dr. med. H. Ch.

Harzmann (8) carried out a study, in which he evaluated the basis of suitable parameters of the formetric unit. According to this study the most important parameters for the differentiation are the pelvis tilt, the lateral deviation (rms) and the rotation (rms), for which the limit values for the differentiation have been set as follows:

Scoliotic malposition
- Pelvis tilt more than 5mm
- Lateral deviation (rms) more than 5mm
- Rotation (rms) less than 5°
- Trunk imbalance 7,5 mm

Scoliolis
- Pelvis tilt less than 5mm
- Lateral deviation (rms) less than 5mm
- Rotation (rms) more than 5°
- Trunk imbalance 7,5 mm

In the present study the trunk imbalance and the surface rotation (max) were chosen as relevant 3D parameters. The trunk imbalance and the connected inclination right/left are important parameters for the muscular tension needed for the stabilization of the body.

The surface rotation is an important value for the strain of the neural structures and the zygapophyseal articulation. In the same way a hypertonus of the zygapophyseal muscles is caused by the distortion of the vertebra.

The lateral deviation is no reliable value for our study, due to the fact that other orthopedic criteria could influence the lateral deviation and its compensation.

Pelvis tilt and pelvic torsion as well are to a large extent dependent on orthopedic problems and their compensation with foot orthotics, leg length correction etc.

Bearing in mind these criteria of influence, the chosen parameters appear to be appropriate for our study. In the course of therapy however, all orthopedic parameters are of course of great significance.

In his study with 72 subjects Hackenberg (7) as well had chosen the trunk imbalance and the rotation to be adequate parameters for the differentiation of scoliosis and scoliotic malposition.

2. MATERIAL AND METHOD

2.1. Patient Group And Course Of Investigation

The interdisciplinary collaboration of dentistry with physiotherapy and orthopedics so far had mainly been based on manual, resp. subjective assessments. In February 2003 we developed and started to work with a concept of an instrumental, i. e. data based backup of interdisciplinary diagnosis and therapy.

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The procedure of the method developed in 2003 is as follows:

- Screening by dentist and orthopedist
- 3D-Scan of the spine
- Condylographic examination
- Splint therapy
- 3D control
- Occlusal correction (Ortho, Prosthetics)
- 3D control

After a screening by the dentist and/or the orthopedist, the first step is a 3D scan of the spine by the orthopedist and a condylographic examination by the dentist. In the case of a TMJ disorder a splint therapy with occlusal correction follows. In order to control the efficiency of the splint therapy a second 3D scan is being carried out. After the definite correction of the occlusal situation (according to the indication possibly orthodontic or prosthetic treatment is necessary) a final control check-up of the spine is done by the orthopedist.

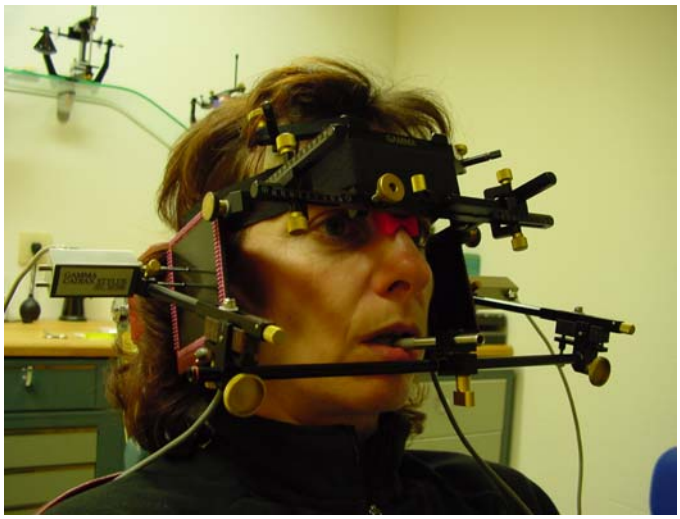
For the present study 60 subjects were chosen, for which a TMJ disease had previously been unequivocally diagnosed. The average TJM displacement of these patients between habitual occlusion and ideal occlusion was 0,8 mm. The minimum displacement was 0,34 mm. Kobayashi had already proven in 1988 (10), that afunctional displacements of only 0,1 mm can already lead to serious dysfunctions of the whole organism.

From the newly developed treatment method the results of the condylography and the 3D scans were taken for evaluation.

2.2. Condylography

For the scan of the horizontal and vertical condyle paths, the condylograph of Messrs. Gamma was used. The subjects to be examined had to bite on cotton rolls or an Aqualizer for 15 minutes, in order to relax the masticatory muscles. The cotton rolls, resp. Aqualizer had been placed near the first molar, when existing, thus producing a relative relaxation and deprogramming of the masticatory muscles.

Patients which could not be relaxed with this method primarily underwent a physiotherapeutic treatment. In this relaxed situation a registration in ideal condyle position had been carried out. For this registration we made a base in the maxilla with Beauty Pink wax. Following the base had been corrected with 4 stops with Aluwax. The stops had been placed in regio 13, 23, 16 or 17 and 26 or 27. The registration was done with no pressure, thus preventing the influence of a cramped muscular system.



Ill. 7 Condylograph

At first the kinematic axis was determined with the condylograph. By means of a paraocclusal gauge in order to fix the mandibular face bow, which allows full tooth contact at all motions, the following motions were registered.

- protrusion path
- mediotrusion path right
- mediotrusion path left
- opening and closing path
- protrusion path under compression of the mandible in cranial direction
- deviation between habitual/centric occlusion and ideal occlusion (MPI)
- speech
- bruxism

The first four movements were done in a relatively relaxed position. During the registrations and due to the passive pressure, resp. the active tension when bruxing, the muscles are getting tighter, thus showing the influence of the muscles on TMJ dysfunctions.

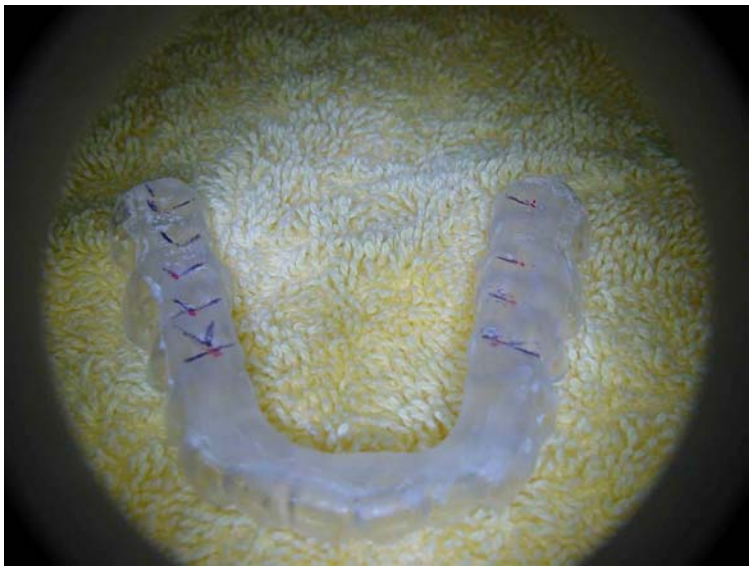
For the present study the following motions were included in the evaluation of the study.

- protrusion path
- protrusion path under compression of the mandible in cranial direction
- deviation between habitual/centric occlusion and ideal occlusion (MPI)

With these values it was possible to diagnose the asymmetry of the occlusion of the subjects. It turned out that the asymmetry directly affects the position of the spine.

By means of a mounting device the splitcast sockled stone models were mounted. The maxilla model in the determined kinematic position, the mandible in the ideal position, determined by the registration. The Reference SL articulator of Messrs. Gamma / Amann/Girrbach was used. This articulator had been individualized with the condylar values supplied by the Gamma software.

With the models mounted this way, an adjusted splint was produced. The splint shows a smooth surface and has no impressions. The splint was made for the mandible, in order to allow osteopathic treatment or manipulations of the skull bones.



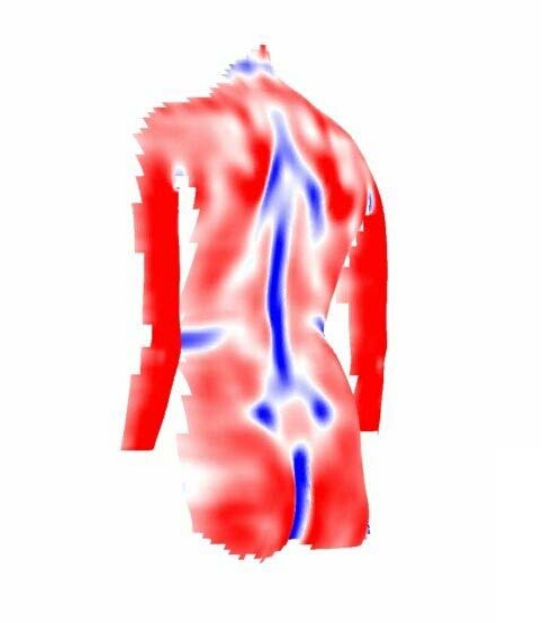
Ill. 8 Splint

2.3. 3D-Scan

For the 3D measurement of the static of the spine the 3D-Scan unit "formetric" of Messrs. Diers was used. This 3D device is scanning the spine in a light optical way, i. e. in a non-invasive manner. The patient is standing frontally in front of a black wall and has to be undressed in the area to be scanned. In a dark room a light projector is lighting the back of the patient with thin horizontal streaks of light. A video camera is recording the reflections of the streaks of light and digitally establishes a surface profile which supplies exact and comparable data about flexion and rotation of the spine and the pelvis. The values can be shown graphically and as data.

Ill. 9 3D-Scan Device (Diers)

Ill. 10 Light Projector

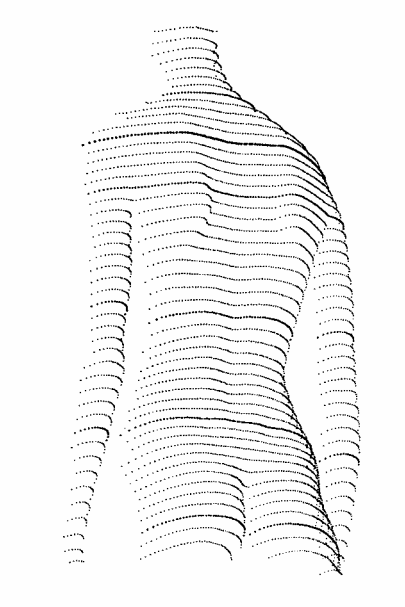


Ill. 11 Surface Profile

Accuracy of the surface calculation

The comparison of a tactile and an optical gauging of a proof phantom at the University of Leuven (Belgium) (9) proved an accuracy of the surface

reconstruction of more than 1 mm. The accuracy of the tactile gauging is within the micron range (millionth of meter - 10-6).



Ill. 12 Surface Calculation

The subjects have been examined this way three times:

- In rest position
- In habitual occlusion
- With occlusal correction

The computer evaluation of the examinations supplied the following data relevant for our study:

- Trunk length
- Trunk imbalance

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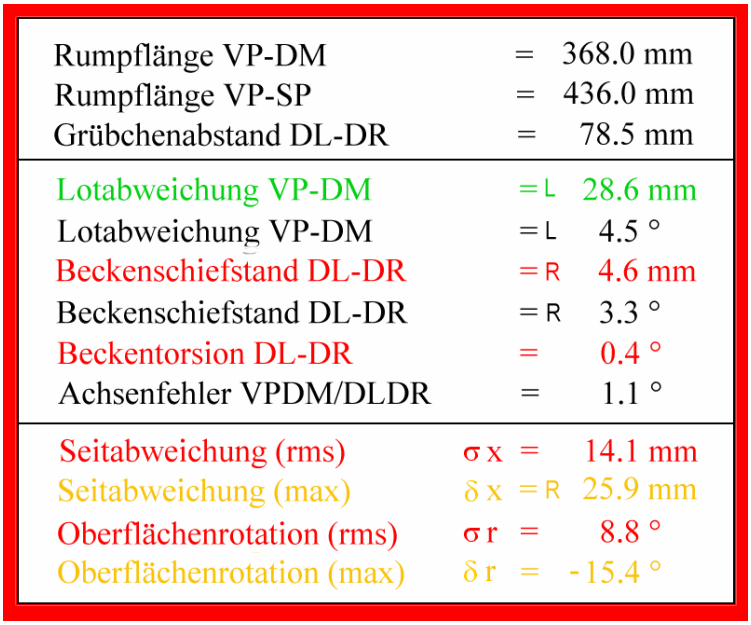
- Pelvis tilt
- Pelvic torsion
- Lateral deviation (rms)
- Lateral deviation (max)
- Surface rotation (rms)
- Surface rotation (max)



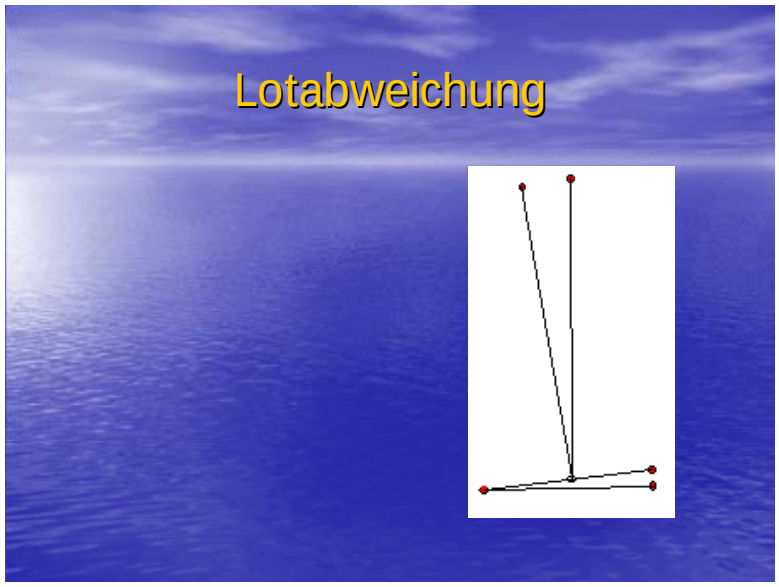
Ill. 13 Example Scanned Values

From this data we separated the values of the trunk imbalance (in mm) and the surface rotation max (in degrees) as these values have a significant influence on the evaluation of TMJ patients.

The trunk imbalance, measured in millimeters, is defined as the lateral deviation of VP from the midline between the lumbar dimples.

A positive value, e. g. R 15 mm means a deviation of VP to the right, a negative value of e. g. L 15 mm- means a deviation to the left.

The surface rotation describes the maximum surface rotation at the apex.



Ill. 14 Trunk Imbalance

The trunk imbalance determines the lateral deviation of plump line from C7 to DM. This lateral deviation of the spine, thus for the whole body is causing an asymmetry in the tension of the trunk musculature. This value therefore correlates with the degree of the deviation of the ideal position of the spine and the pelvis tilt.

The fact that the tension of the trunk musculature is correlating with the tension of the temporomandibular musculature is crucial for the results of our investigation.

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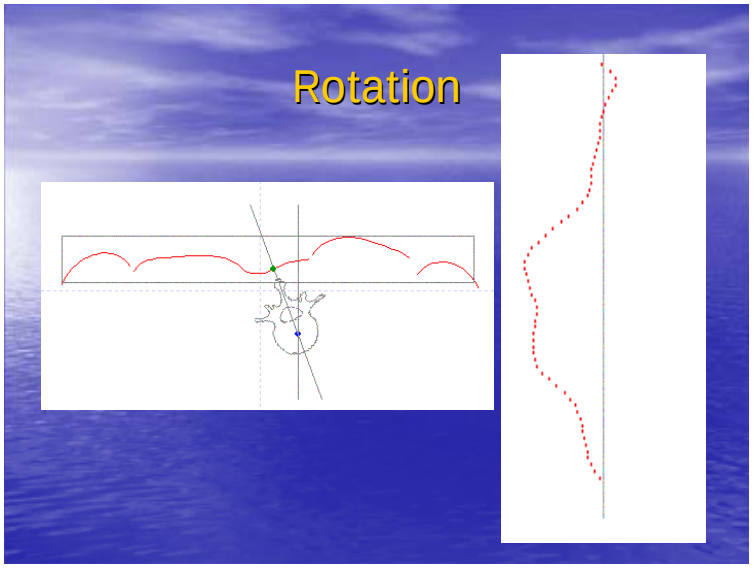

Ill. 15 Rotation

The rotation determines the torsion of the vertebras and is measured in degrees. The ideal value of the rotation is zero, whereas the pathological value is determined at 5 degrees.

The value of the rotation is highly decisive for the degree of the complaints. The neural as well as the muscle and ligament structures do not permit an excessive rotation between the vertebra. In the course of the investigation it could be proved that it is possible to positively influence the rotation by means of an occlusal correction.

Ill. 16 and 17 show the different positions of a spine with and without occlusal correction. The trunk imbalance as well as the maximum lateral deviation were visibly improved after occlusal correction.

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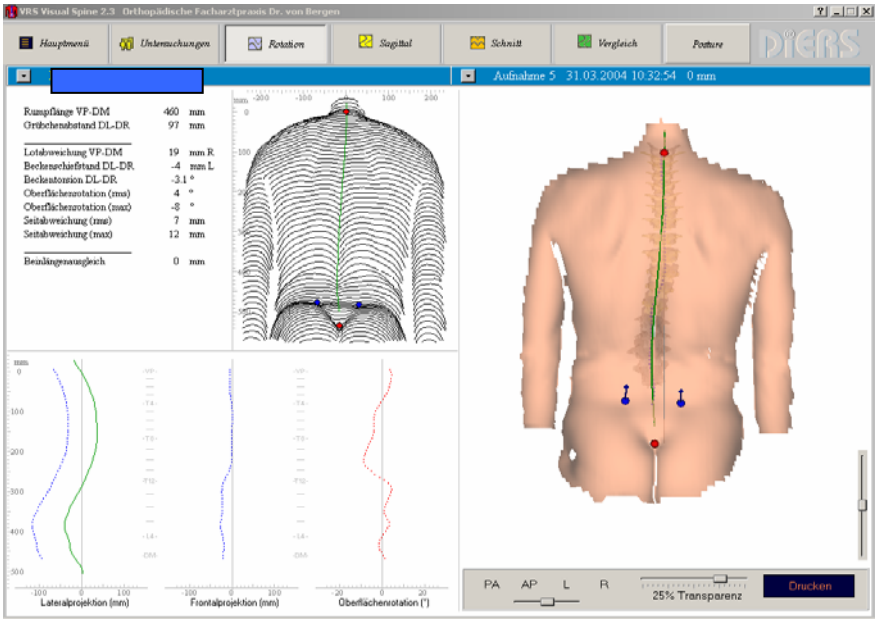
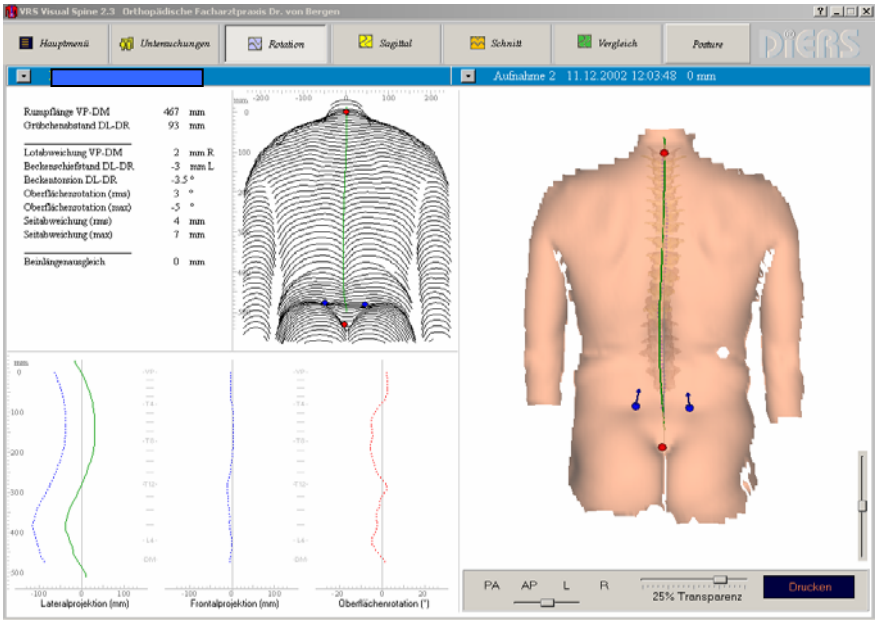
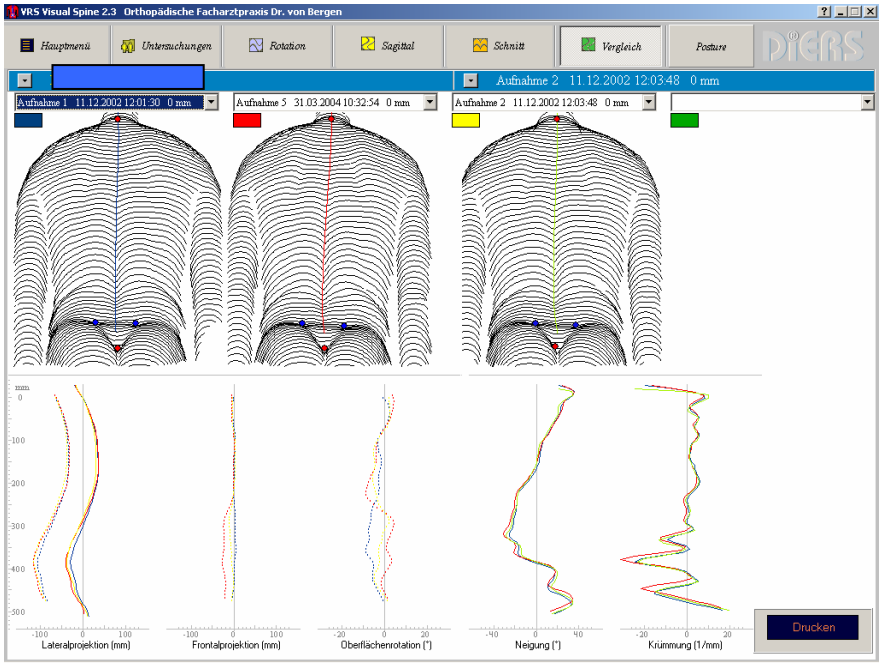


Ill. 16 Position Of Spine In Habitual Occlusion



Ill. 17 Position Of Spine With Bite On Splint

Ill. 18 shows the comparison of the measurements in resting position, habitual occlusion and occlusion with adjusted splint.



Ill.18 Blue – Rest position
Red – Habitual Occlusion
Yellow – With Occlusal Correction

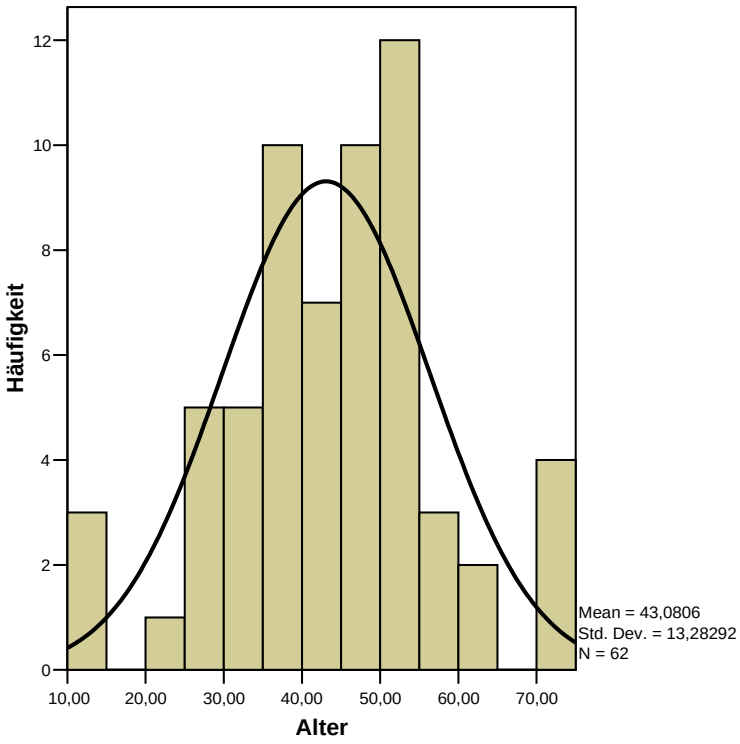
3. RESULTS

3.1. General Results

60 subjects were examined in this study, 31 patients were females and 29 patients were males. The age of the patients varied between 10 years and 71 years.

The selection was done arbitrarily. Main criteria was the pain syndrome and the will for therapy.

Age distribution:



Tab. 1 Age Distribution

3.2. Results With Regards To Dental Aspects

Total	Dental criteria				
			Limitation		
No.	Clicking	Muscular	both sides	right	left
60					
N=					
Single values	23	60	14	9	7
Single values in %	38,3%	100,0%	23,3%	15,0%	11,7%
Group values	23	60		30	
Group values in %	38,3%	100,0%		50,0%	

Tab. 2 Dental Criteria 1

Total	Dental criteria						
	Compression				Loss of supporting area		
No.	both sides	right	left	Side shift	both sides	right	left
60							
N=							
Single values	22	6	23	16	10	2	26
Single values in %	36,7%	10,0 %	38,3 %	26,7 %	16,7%	3,3%	43,3 %
Group values		51				38	
Group values in %		85,0 %				63,3%	

Tab. 3 Dental Criteria 2

3.2.1. Joint Clicking

Joint clicking was noted in 38,3 %, resp. 23 subjects out of 60.

3.2.2. Muscular Hypertonus

The muscular component was a strong factor with all examined patients. All 60 patients, resp. 100% showed an increased tonus of the closing muscles.

3.2.3. Limitation

Limitation was found with 30 patients, resp. 50%. 9, resp. 15 % on the right, 7, resp. 11,7% on the left temporomandibular joint. Limitation on both sides was found with 14 patients, resp. 23,3%.

3.2.4. Compression

The examinations of the compressability of the joints showed a significant compression with 51 patients, resp. 85%. 23, resp. 38,3% showed a compression in the left joint, 6, resp. 10% a compression in the right joint and 22 subjects, resp. 36,7% on both sides.

3.2.5. Lateral Shift

A lateral shift in the terminal occlusion was found in 16, resp. 26,7% of the cases.

3.2.6. Loss Of Supporting Area

A loss of supporting area was found with 38, resp. 63,3% of the probands. 26 subjects, resp. 43,3% showed a loss of supporting area on the left side and 2 subjects, resp. 3,3% on the right side. A loss of supporting area on both sides was the case in 16,7%, resp. 10 subjects.

3.2.7. Condylography

3.2.7.1. MPI (Mandibular Position Index)

This value is measuring the difference of the mandibular malposition between relaxed position and habitual occlusion. The deviation of the temporomandibular joints varied between a minimum of 0,11 mm and a maximum of 1,55 mm. The mean deviation was 0,84 mm.

3.2.7.2. Resilience

The value of the resilience defines the distance of the protrusion and retrusion paths. They are being recorded in relaxed muscle position with and without cranial pressure of the practitioner. The mean measured values were 0,49 mm on the left side and 0,48 mm on the right side.

3.3. Orthopedic Results

Total	Orthopedic criteria		
No.	Neck problems	Headache	Musculo-skeletal system
60			
N=			
Single values	59	41	57
Single values in %	98,3%	68,3%	95,0%

Tab. 4 Orthopedic Criteria

3.3.1. Neck Problems

59 resp. 98,3% of the examined subjects complained about neck pain, e.g. whiplash injuries.

3.3.2. Headache

41 patients, resp. 68,3% of the probands complained about headache.

3.3.3. Problems In The Musculoskeletal System

Complaints in the musculoskeletal system beneath the cervical spine were diagnosed with 57 persons, resp. in 95,0% of the cases.

3.3.4. 3D Scan Of The Spine

3.3.4.1. Trunk imbalance

3.3.4.2. Rotation

The evaluation of the data showed an improvement of the trunk imbalance in 71,7 % of the cases and an improvement of the rotation of the spine in 68,3 % of the cases.

Statistical comparison of the scanned values with and without splint

3.3.4.1. Trunk Imbalance

Paired Sampling Statistics

		Mean Value	N	Standard deviation
	Trunk imbalance without splint	7.4000	60	5.93239
	Trunk imbalance with splint	4.4000	60	5.06634

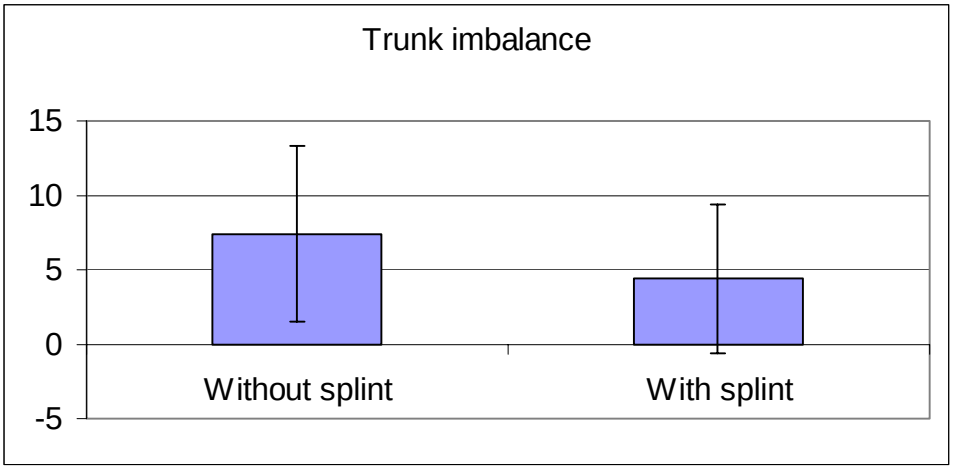
Tab. 5 Paired Sampling Statistics Trunk Imbalance

Test with paired samplings

		Paired differences		T	df	Sig. (2-sides)
		Mean value	Standard deviation			
Pairs 1	Trunk imbalance without splint-Trunk imbalance With splint	3.00000	5.63283	4.125	59	< 0,001

Tab. 6 Test With Paired Samplings Trunk Imbalance

A highly significant difference ($p < 0,001$) was discovered in the scanning of the probands with and without splint. The mean difference was 3,00 mm.



Tab. 7 Table Trunk Imbalance

Ranks

		N	Rank average	Rank total
Trunk imbalance with splint – Trunk imbalance without splint	Negative ranks	43	27.67	1190.00
	Positive ranks	11	26.82	295.00
	Connections	6		
	Total	60		

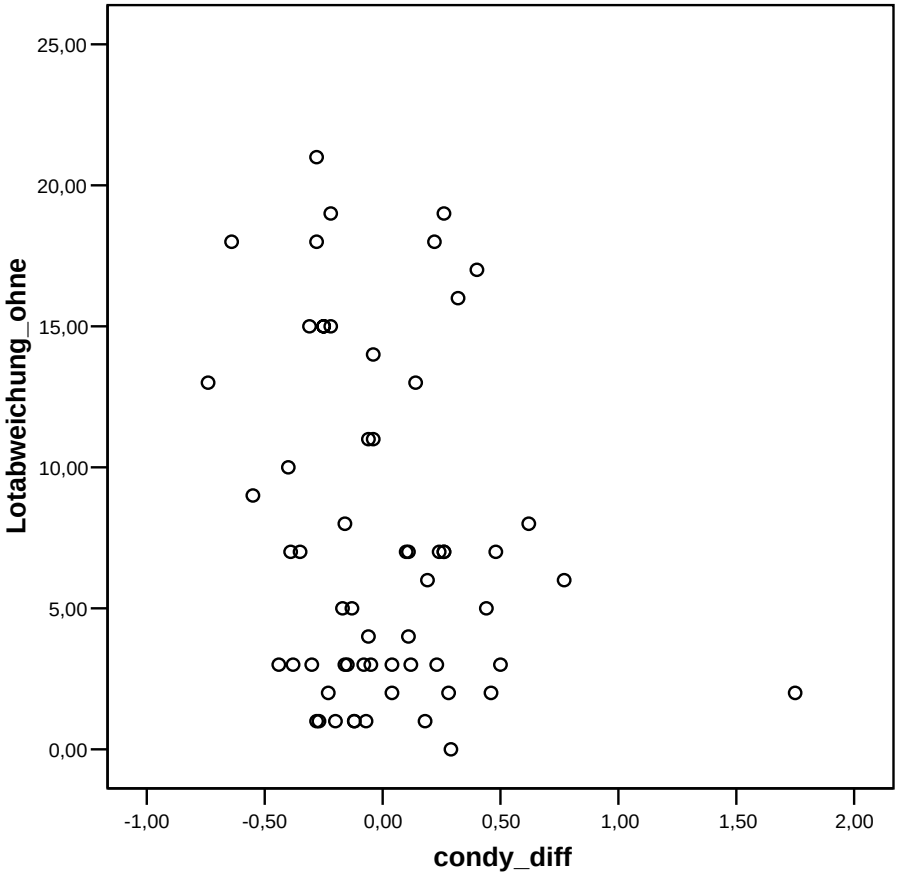
Tab. 8 Ranks Trunk Imbalance

43 (71,7%) patients showed a higher trunk imbalance value without splint than with splint, with a proportional reduction of 64,4%.

11 (18,3%) patients showed a lower trunk imbalance value with splint than without splint with a proportional increase of 216,2%.

6 (10%) patients showed equal scan values with and without splint.

No significant interrelationship of the scanning with and without splints was detected between the deviation right/left of the condylographic examination and the values of the trunk imbalance (p=0,160 r= - 0,190).



Tab. 9 Correlation Trunk Imbalance

3.3.4.2. Rotation

Statistic with paired samplings

		Mean value	N	Standard deviation	mean value
Pairs 1	Rotation without splint	7.5167	60	3.65686	.47210
	Rotation with splint	5.4500	60	2.58696	.33398

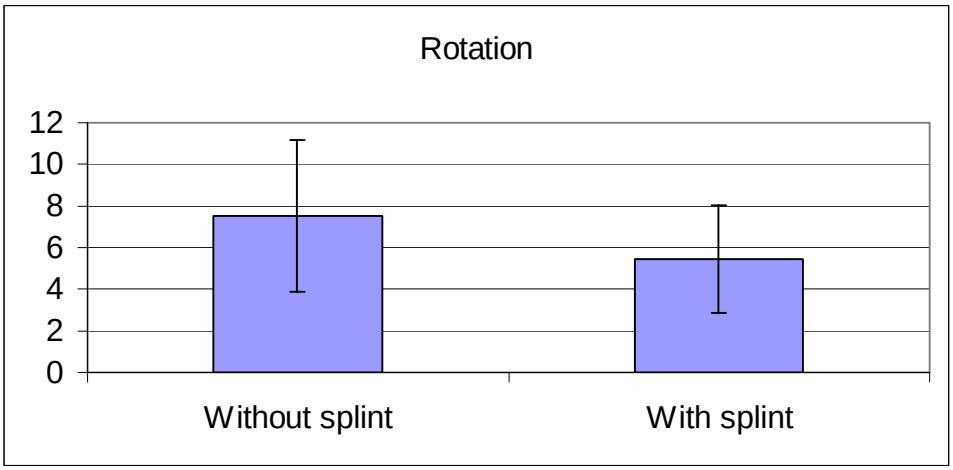
Tab. 10 Statistics With Paired Samplings

Test with paired samplings

		Paired difference		T	df	Sig. (2-sides)
		Mean value	Standard deviation			
Pairs 1	Rotation without splint - Rotation with splint	2.06667	3.01896	5.303	59	< 0.001

Tab. 11 Test With Paired Samples Rotation

A highly significant difference ($p < 0{,}001$) could be determined when scanning with and without splint. The mean value of the difference was 2,06 degrees.



Tab. 12 Illustration Rotation

		N	Rank Average	Rank Total
Rotation with splint – Rotation without splint	Negative Ranks	41(a)	29.21	1197.50
	Positive Ranks	11(b)	16.41	180.50
	Connections	8(c)		
	Total	60		

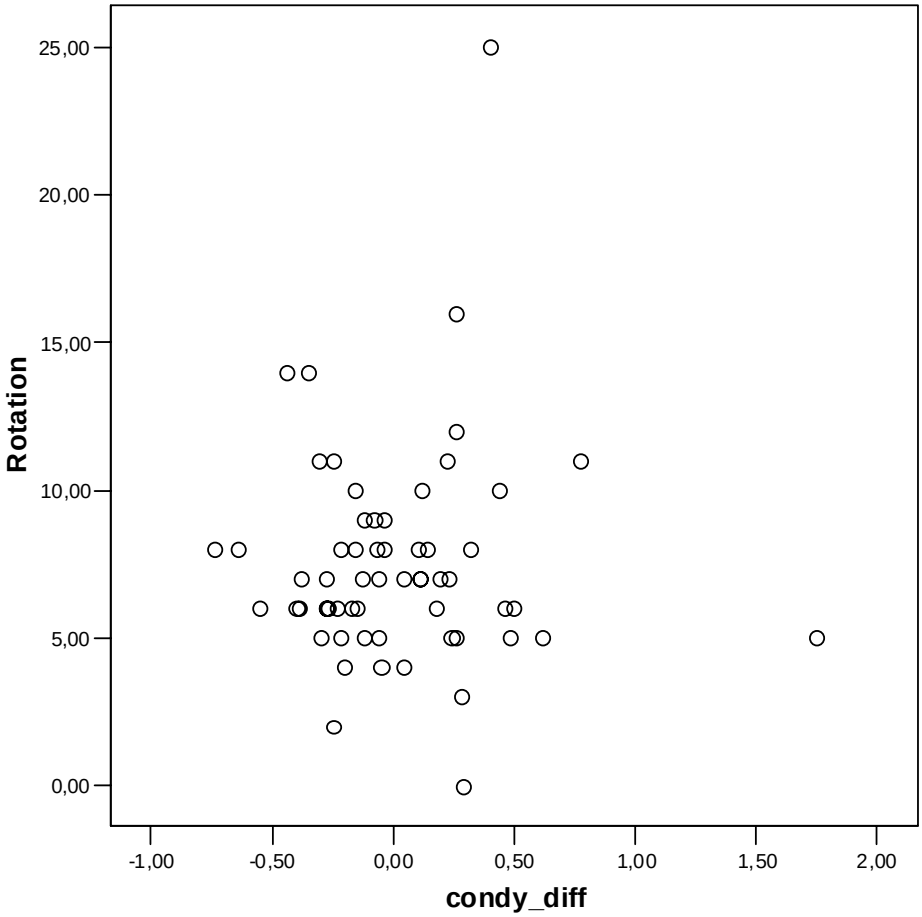
Tab. 13 Ranks Rotation

41 (68,3%) patients showed a higher degree of the deviation in rotation without splint than with splint, with a proportional decrease of 39%.

11 (18,3%) patients showed a lower degree of the deviation in rotation without splint than with splint, with a proportional increase of 27%.

8 (13,3) patients showed an equal value of the deviation in rotation with and without splint.

No significant interrelationship of the scanning with and without splints was discovered between the deviation right/left of the condylographic examination and the values of the deviation in rotation (p=0,911 r= 0,015).



Tab. 14 Correlation Rotation

4. CONCLUSION

4.1. Interpretation Of Results

4.1.1. Results With Regards To Dental Aspects

4.1.1.1. Joint Clicking

Joint clicking is a clear symptom for a damage of the structures, resp. a dislocation of the articular disc and in this study is being documented amongst the other results. Nevertheless joint clicking itself is not a relevant parameter for the judgement of a temporomandibular dysfunction.

4.1.1.2. Muscular Hypertonus

Tense masticatory muscles were found in all cases. This was no basic criteria for this investigation, regardless this to be the main component for the temporomandibular disorder. The asymmetry of the masticatory muscles, caused by the muscular component, transmits the asymmetry to the whole musculoskeletal system.

4.1.1.3 Limitation

The limitation of 50% of all examined subjects even showed a structural damage of the temporomandibular system. This is not surprising as all examined subjects had been diagnosed with a long-standing and serious from of temporomandibular disorder.

4.1.1.4 Compression

A much higher share (85 % of the cases) were suffering from compression of one or both joints. Compared to the other examined criteria the

compression is to be regarded as the most influential and most dangerous component of the temporomandibular disorder.

4.1.1.5. Lateral Shift

Lateral shift in the terminal occlusion correlates with an asymmetric muscle tension and thus can cause problems in the spinal system.

4.1.1.6. Loss Of Supporting Area

A loss of the supporting area was the most detected fact of the investigation. The loss of the supporting area, combined with a hypertonus of the closing muscles finally results in a compression of the temporomandibular joints. In case of a loss of the supporting area on one side only it is joined by an additional asymmetric tension of the musculature.

4.1.1.7. MPI

The value of the mandibular positional index clearly shows that the position of the mandible in the terminal occlusion deviates from the physiological "centric" position. Based on the fact that medical science defines 1/10 mm as the pathological limit for complaints (17), the average value of 0,84 mm of the examined subjects in this study considerably deviates towards negative from the average. Even the minimum deviation of 0,11 was above the threshold value of 0,1 mm.

4.1.1.8 Resilience

The resilience was measured in cranial direction. Due to the fact that the morphological structure of the base of the skull is limiting the shift, a mean value of 0,49 mm on the left side and 0,48 mm on the right is to be considered an important criteria of influence. It is quite plausible that the MPI value is higher than the value of the resilience, as the MPI represents the deviation in a three dimensional direction and the lateral deviation has a considerably higher range.

4.1.2 Orthopedic Results

4.1.2.1. General Orthopedic Results

Here the frequency of occurrence of neck (cervical spine) problems, headache and problems in the complete musculoskeletal system were investigated. The extremely high percentage of such orthopedic symptoms of 98,3 % of neck problems, 68,3 % of headache and 95,0 % of problems in the complete musculoskeletal system clearly demonstrate the complex interrelation of the temporomandibular disorder. Due to the fact that after termination of a splint therapy 70 % of the probands showed an improvement of their spinal position and at the same time an elimination of their orthopedic complaints, a direct interrelation between orthopedic and dental problems can be concluded.

4.1.2.2. 3D-Scan Of The Spine

The values of the trunk imbalance show a highly significant difference ($p<0,001$) in the scans with and without splint. As mentioned before, the critical value of a trunk imbalance is defined as 7,5 mm. Measured values above this value are considered to be pathological. In the present investigation a mean reduction of the value of the trunk imbalance from 7,4 mm to 4,4 mm could be achieved. It has to be emphasized that after termination of the splint therapy 80% of the subjects showed a value below the pathological limit.

Although the values of the correction with regards to the rotation were slightly lower, the approximation to the limiting value and an objective success rate of 68,3% is to be considered as clearly positive. Upon reflection of this result it has to be considered also that the rotation, as well as pelvic rotation very often interrelates with other orthopedic criteria. Both values, the trunk imbalance as well as the rotation could not prove a

significant interrelation of the degree of the temporomandibular dysfunction and the degree of the spinal malposition.

4.2. Consequences Of The Research

Conclusion of this investigation is that approx. 70% of the TMJ patients experienced after the occlusal correction a correction of their cervical spine as well. Observations of Ridder (14) state that 70 – 80% of the cervical spine syndromes are strongly interrelating with a TMJ disorder, resp. a malposition of the mandible. Thus it would strongly be recommended to examine these patients interdisciplinarily and to establish a coordinated diagnosis and mutual therapy planning. Since based on these and similar investigations temporomandibular dysfunctions very often affect spinal problems and the muscular tension connected with it.

It is understood that a TMJ disorder cannot be considered as the only cause, however, very often the temporomandibular dysfunction is an important component and thus should be considered or eliminated as a possible causal factor in the therapy.

The results clearly show as well that the problematic nature of a TMJ disorder must not be neglected in planning prosthetic restorations. The checkbite in physiological position as a determining component should be considered essentially important.

A checkbite should never be taken in a situation when the masticatory muscles, the back muscles or generally the whole musculature of the musculoskeletal system is tense. This applies to the physical state of the patient after long preparations as well as for patients suffering from muscular hypertonus due to other medical cause, such as traumatic states

after accidents or other orthopedic problems. Under no circumstances causes should be neglected attributing to psychic facts. All in all a TMJ screening should take place in any case.

4.3. Review Of Outcome

The present investigation exclusively deals with extreme cases of TMJ disorders. Scientific investigations came to the conclusion that the perception of occlusal obstacles start at 1/10 mm (17). If the obstacle is permanent and at the same time the patient is exposed to an increased stress influence, bruxism and the muscular tension arising from it, might lead to a TMJ disorder (7). In the present investigation the psychic component was taken into consideration by using the a specific "stress questionnaire" of the University of Hamburg. (app. 7.2.).

The mean deviation of the temporomandibular joints of the examined subjects was 0,84 mm in habitual and neutral (centric) occlusion.

Other scientific investigations have proved that patients with serious occlusal dysfunctions showed no complaints. This phenomenon however was not subject of our investigation.

The present investigation exclusively examined and treated patients with a need for treatment of their TJM disorder. All patients were definitely diagnosed with a TMJ dysfunction. The study aimed to prove the interrelation of an occlusal malposition and the spinal position. The results unambiguously prove that to a high degree an occlusal correction has a positive influence on the position of the spine.

Problem of the condylography:

The weak point of condylographic recordings are inaccuracies occurring from wrong handling and/or off-centered face bows. In order to eliminate these errors, a reference recording of the protrusion/retrusion should be taken after determination of the reference point (centric). This movement will be repeated after diagnostically relevant recordings, thus avoiding a deviation through manipulation or off-centered face bows.

An additional certainty is being achieved when passive pressure on the mandible towards cranial and active muscle tension when bruxing are on the same level and both movements are significantly more cranial than the free protrusion movement. Hereby it can be assumed that the temporomandibular joint is suffering from compression and a manipulative deviation can be excluded.

4.4. Interesting Observations And Results

Compression

The loss of the supporting zone was determined from the instrumental functional analysis and the analysis of the model after location of the kinematic axis and the "centric" registration. Due to the fact that 76% of the probands were older than 35 years and had prosthetic restorations, a manipulation of the practitioner seems likely for the cause of the loss of the supporting area.

Suggestions For Further Investigations

An important question in the interdisciplinary judgement of the influence on the spine is the change of the pelvis tilt. As this parameter very much depends on orthopedic measures as well, like foot orthotics and leg length corrections, an interdiciplinary investigation of the "ascending problem" and its influence on the temporomandibular system would be of great interest.

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6. GLOSSARY

3D Scan	Threedimensional light-optical scan of the spine.
Apex cervical lordosis	Point of the most cervical curvature of the spine.
Apex kyphosis (KA)	Point of the most thoracal curvature of the spine.
Apex lumbar lordosis (LA)	Point of the most lumbar curvature of the spine.
Bite registration	Usually a wax record of an occlusal relationship between the maxilla and mandible, used in the mounting of casts on an articulator. Lately new bite registration materials have been developed in light-curing resin.
Compression	Stress created by two sets of forces with the same line of action and senses towards each other. In our context the force within the joint is created by muscle tension.
Condylography	Threedimensional scan of the condyle paths.
Craniomandibular System	A collective term for the masticatory apparatus with all its bony, muscular, nerval and cartilaginous elements.
DM	Midpoint between lumbar dimples left and right.
Flèche cervicale/Flèche lombaire	Distances of the body surface with a vertical tangent at the Apex cervical lordosis and Apex lumbar lordosis. Ideally the distances of the body surface and the tangent are cervically and lumbally equal.
Habitual occlusion	Mandibular position dictated by maximum and habitual intercuspation of the maxiliary and mandibular teeth, it is a dentally determined position, independent of condylar position.
ICT	Turning point of cervical and thoracal curvature of the spine.
ILS	Turning point of lumbar and sacral curvature of the spine.
Inflectional Point (ITL)	Maximum lateral tilt beneath the kyphotic angle. Turning point of thoracal and lumbar curvature of the spine.
Kinematic axis	The connecting axis of the conduli articularis where the temporomandibular joints rotate in their most cranial and retral position.
Kyphotic angle	Defined through inflectional point ITC and ITL. The angle of the body surface at the cervico-

	thoracal curvature to a vertical tangent and the thoracic-lumbar curvature to a vertical tangent.
Lateral deviation	Deviation of spinal midline, measured from the line VP-DM.
Lordotic angle	Defined through inflectional point ITL and ILS. The angle of the body surface at the thoracic-lumbar curvature at ITL and the lumbo-sacral curvature at ILS.
Loss of supporting area	Missing molars in order to support the masticatory forces.
MPI	Mandibular position index. The MPI describes the position of the temporomandibular joints in physiological position and habitual occlusion.
Paraocclusal gauge	Securing device of the mandibular face-bow where the occlusal planes remain free for the functional measurement.
Pelvic torsion	Mutual torsion of both lumbar dimples with relation to the normal plane.
Pelvis tilt	Difference in level of the lumbar dimples, referring to a horizontal level.
Resilience	The property of a material that represents its ability to store mechanical energy without permanent deformation.
Rest position	The mandibular position assumed when the head is in an upright position and the involved muscles, particularly the elevator and depressor groups, are in equilibrium in tonic contraction, and the condyles are in a neutral, unstrained position.
Rotation	Torsion of the vertebra. The limit value of a healthy person is defined as 5 degrees.
Sacrum point	Beginning of the Rima ani.
Scoliosis	Malposition of the spine due to structural causes.
Scoliotic malposition	Malposition of the spine due to functional causes.
TMJ disorder	A collective term embracing a number of clinical problems that involve the masticatory musculature, the temporomandibular joint (TMJ) and associated structures, or both. Temporomandibular disorders have been identified as a major cause of nondental pain in the orofacial region and are considered to be a

	subclassification of musculoskeletal disorders.
Trunk Imbalance	Lateral distance of VP from the midline between the lumbar dimples. The limit value of a healthy person is defined as 7,5 mm.
Trunk length	Spatial distance of Vertebra Prominens and midpoint of lumbar dimples left and right.
Vertebra prominens (VP)	The most prominent point of the cervical spine at C7.

Interdisciplinary Treatment of TMJ Disorder In Conjunction With Orthopedic 3D Scan

7. APPENDIX

7.1. Questionnaire "Klinische Funktionsanalyse"

7.2. Psychological Questionnaire "Streßfragebogen"

7.3. Evaluation Form "Condylographie"

7.4. Evaluation Form "3D-Vermessung"