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Vzájemný vztah mezi asymetriemi v orofaciální oblasti a křivkami páteře

The relationship between orofacial asymmetries and spinal curves

Bakalářská práce

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Abstrakt

Klíčová slova: temporomandibulární kloub, poruchy temporomandibulárního skloubení, malokluze, skolióza, moiré, postura, křivky páteře

Cíl:

Cílem práce bylo určit, zda probandi s patologiemi v orofaciální oblasti (malokluze, poruchy temporomandibulárního skloubení, deviace pohybu mandibuly) mají vyšší prevalenci skoliózy a jiných deviací páteře než probandi bez patologií v orofaciální oblasti.

Metodiky:

U 24 zdravých dobrovolníků (2 muži, 22 žen, průměrný věk 21,54 let) jsme změřili následující parametry orofaciální oblasti: statický skus (rovina skusu, deviace středních čar zubních oblouků), pozici mandibuly vůči maxile v sagitální rovině (overjet, overbite), a také rozsah a symetrii pohybů mandibuly (protruze, maximální otevření úst). Parametry páteře byly naměřeny pomocí moiré topografie na přístroji Diers formetric 4D, který naměřená data počítačově zpracuje do 3D snímku páteře. Měřili jsme skoliotický úhel, kyfotický a lordotický úhel, maximální a průměrnou rotaci obratlů, inklinaci a imbalanci trupu, fleche cervicale, fleche lombaire a také amplitudu laterálních odchylek páteře. Abychom odhalili možné vztahy mezi parametry orofaciální oblasti a páteře, využili jsme Spearmanův korelační koeficient a Mann-Whitney U test.

Výsledky:

Statistická analýza neodhalila žádný vztah mezi skusem a parametry páteře. Byl však odhalen vztah mezi skoliotickým úhlem a pohybem mandibuly. Probandi s deflekčním typem otevírání (Mdn = 15) mají statisticky významně vyšší skoliotický úhel než probandi se symetrickým typem otevírání (Mdn = 10). Jedinci s deflekčním typem otevírání (Mdn = 13,16) měli také vyšší amplitudu laterálních odchylek páteře než jedinci se symetrickým typem otevírání (Mdn = 7,44). Co se týče průměrné rotace obratlů, jedinci s deflekčním typem otevírání (Mdn = 4,39) a také jedinci s deviačním typem otevírání (Mdn = 3,40)

měli signifikantně vyšší stupeň rotace než jedinci se symetrickým typem otevírání (Mdn = 2,22).

Závěr:

Vztah mezi skusem a posturou zůstává stále nejasný z důvodu multifaktoriální etiologie jak posturálních poruch, tak poruch skusu a temporomandibulárního skloubení. Byla ale odhalena vzájemná souvislost mezi typem pohybu mandibuly a posturou v následujících parametrech: skoliotický úhel, průměrná rotace obratlů a amplituda laterálních odchylek páteře. Pakliže jsou přítomny poruchy temporomandibulárního skloubení, změní se trajektorie pohybu mandibuly a jelikož temporomandibulární kloub je jedním z nejvíce používaných v lidském těle, mohou tyto změny ovlivnit celou posturu.

Abstract

Key words: temporomandibular joint, temporomandibular joint disorder, malocclusion, scoliosis, moiré, posture, spinal curves

Goal:

Our attempt is to determine whether subjects with pathologies in the orofacial area (malocclusion, TMJ disorders, jaw movement deviations) have higher prevalence of scoliosis or other spinal deviations than subjects without pathologies in the orofacial area.

Methods:

In 24 healthy young volunteers (2 men, 22 women; mean age 21,54 years) we measured following parameters of the orofacial area: occlusal parameters in static position (occlusal plane, midline deviation), position of the mandible (overjet, overbite) and also mandible movement parameters (protrusion, maximal mouth opening, mouth opening symmetry). Spinal parameters were measured using Video-Raster-Stereography device: Diers formetric 4D, a moiré topography based computerized system. We measured the scoliosis angle, kyphotic and lordotic angle, rotation of the vertebrae (maximal and mean), trunk inclination, trunk imbalance, fleche cervicale, fleche lombaire and also the amplitude of lateral deviations. To reveal possible relationships between parameters from the orofacial and spinal region Spearman's rank-order correlation or Mann-Whitney U test was performed.

Results:

Statistical analysis did not reveal any relationship between occlusal parameters in static position and spinal parameters. However, we found significantly higher scoliosis angle in subjects with mandibular deflection (Mdn = 15) compared to subjects with symmetrical mouth opening (Mdn = 10). Individuals with mandibular deflection (Mdn = 13.16) had also significantly larger amplitude of spinal lateral deviations than individuals with symmetrical mouth opening (Mdn = 7.44). In case of vertebral rotation RMS parameter, individuals with mandibular deflection (Mdn = 4.39) and individuals with

mandibular deviation (Mdn = 3.40) have significantly higher degrees than individuals with symmetrical mouth opening (Mdn = 2.22).

Conclusion:

The relationship between occlusion and posture remains still unclear, because of the multifactorial etiology of postural and occlusal and temporomandibular disorders. Nevertheless, we found interdependence between jaw movement and posture in following parameters: scoliosis angle, vertebral rotation and amplitude of lateral deviations. When pathologies of the TMJ are present, the jaw pathway is altered and as the TMJ is one of the most loaded joints in the human body, these alterations can possibly influence the whole body posture.

CONTENT

There is much more than bones and muscles.
There is an entire world hidden inside ourselves able to make us miserable and able to make our life better. A kind of inner pharmacy always available to be used.

Davide Lanfranco inspired by Dr Giancarlo Russo

1 INTRODUCTION

There is an increasing prevalence of malocclusion in population according to transition to soft diet (Corruccini, 1982). These changes can happen within one generation or even in shorter time frame (Bailey, 1999).

Simultaneously we can observe in today population a great prevalence of poor posture and scoliosis, which is caused mainly by the sedentary lifestyle and lack of movement, but may there also be connection with increasing numbers of malocclusion?

It is well known that sprained ankle changes function of the hip muscles, or hip dysplasia is often tied with low-back pain and scoliosis. But may something so small like occlusion influence something as big as spinal curves?

The primary notion was that if there is an inter-relationship between the stomatognathic system and the cervical spine posture, the cervical spine posture may further influence the spinal curves and overall body posture (Armijo-Olivo et al., 2013; Silveira et al., 2015). That means that asymmetry in the orofacial area or in the stomatognathic system can through muscle-fascial chains disturb cervical spine posture and possibly cause trunk imbalance and/or scoliosis. It is already known, that scoliosis is connected to orofacial asymmetries (Lulić-Dukić, 1986), but does it work also reversely?

A growing body of literature has evaluated the relationship between dental occlusion, temporomandibular joint and posture. A recent review (Amat, 2009) found 131 articles concluding that the occlusion affects posture and 171 asserting that posture affects occlusion.

Of interest are four studies made on rats (Fajardo et al., 2016; D'Attilio et al., 2005; Festa et al., 1997; Ramirez-Yanez et al., 2015). All of them confirmed that unilateral raising/opening of the occlusion cause increase in the Cobb angle in 1-2 weeks (initial Cobb angle in average 1.42°; after two weeks with unilaterally raised occlusion average Cobb angle 15.17°). After restoring occlusal harmony by raising/opening also the other side of the occlusion, the spinal column straightens up almost to the initial Cobb angle. No alterations of the vertebral alignment were found in the control group of rats.

D'Attilio et al. (2005) focused on sagittal morphology of the face and found correlation between Class II malocclusion and higher extension of cervical lordosis, resp. forward head posture (Gadotti et al. 2005). Subjects with Class III malocclusion showed lower cervical lordosis.

Zhou et al. (2013) found significant relationship between lateral shift of the mandible and scoliosis ($p < 0.01$).

A key problem in much of the literature in relation to this topic is the absence of holistic view. There are many authors who want to prove, that malocclusion is a cause of scoliosis. They omit a great number of factors, that can also be responsible for poor posture, for example different leg length, psychological profile of the patient, genetic dispositions, developmental coordination disorder and many others…

Within the scope of our work is not a longitudinal study of subjects before and after interventions in the stomatognathic system, but we aimed to find out, if the pathologies or asymmetries in the orofacial area are often present in subjects with spine curvature disorders. Our research is suggested to compare different parameters of the orofacial area to parameters of the spine curvature.

2 THEORETICAL PART

In the theoretical part of this study are explained the basic anatomical and pathophysiological principles that may be responsible for chaining of the orofacial asymmetries and disorders further to the body system. Moreover, the relevant physiotherapy approaches dealing with referred pain and kinetic chains are mentioned to support the theoretical basis of this work.

2.1 Masticatory system

2.1.1 What is masticatory system

The masticatory system is a highly refined functional unit made of bones, joints, ligaments, muscles and teeth. Primary function is chewing, swallowing and speaking. The whole system is regulated and coordinated by intricate neurological controlling system (Okeson, 2008).

2.1.2 Anatomy of the masticatory system

There are 3 bones included in the masticatory system: maxilla, mandible and the temporal bone. All skeletal components of the scull have fused together during the development except the mandible, which is joined by the temporomandibular joint. The maxillary teeth are also considered to be a fixed part of the scull (Okeson, 2008).

The articulation between mandible and the temporal bone is called temporomandibular joint. It is classified as a compound joint created by caput mandibulae and mandibular fossa, which are separated by the articular disc. The articular disc is made of dense fibrous connective tissue and its main purpose is to separate, protect and stabilize the condyle in the mandibular fossa during movement. The anterior region of the disc is attached by tendinous fibres to the superior lateral pterygoid muscle, the posterior region is attached to the retrodiscal tissue, which is highly vascularized and innervated (Okeson, 2008).

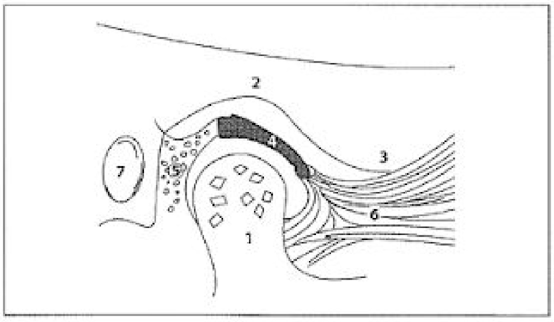


Figure 1 The anatomy of the temporomandibular joint, a picture from Machoň (2008). There are following components: 1 – mandibular condyle, 2 – mandibular fossa, 3 – eminence, 4 – articular disc, 5 – retrodiscal tissue, 6 – lateral pterygoid muscle, 7 – auditory canal

For the stabilizing function of the joint are responsible the ligaments. The ligaments protect the structures of the joint and limit border movements. There are 4 ligaments: lateral ligament, medial ligament, sphenomandibular ligament and stylomandibular ligament (Machoň, 2008). Okeson (2008) considers three functional ligaments: (1) the collateral ligaments, (2) the capsular ligament, and (3) the temporomandibular (TM) ligament, and two accessory ligaments (4) the sphenomandibular and (5) the stylomandibular ligament.

5 pairs of muscles belong to the masticatory system: musculus masseter, musculus temporalis, musculus pterygoideus lateralis, musculus pterygoideus medialis, musculus digastricus. These muscles provide movement of the mandible and stabilize the temporomandibular joint (Machoň, 2008).

Machoň (2008) speaks about 4 specificities of the temporomandibular joint: (1) it is the only joint in human body capable of two movement types (hinging and gliding movement); (2) it is a pair joint – both joints are involved in each movement and also a dysfunction of one temporomandibular joint affects functioning of the other temporomandibular joint; (3) the articular space is separated by the articular disc in two noninteracting spaces; (4) the temporomandibular joint is one of the most loaded joints in human body (average adult opens his mouth approximately 1800 times a day according to Harrison, 1997).

The human permanent dentition is made of 32 teeth equally distributed between the upper and lower jaw. Teeth are aligned in the alveolar processes of the jaw and together build a dental arch. The maxillary dental arch is larger than the mandibular dental arch, which causes overlapping of the maxillary teeth. Okeson explains this using two facts: (1) maxillary teeth are wider than mandibular teeth, (2) maxillary anterior teeth have greater facial angulation than mandibular anterior teeth (Okeson, 2008).

Figure 2 The difference between maxillary and mandibular dental arch, a picture from Machoň (2008)

2.1.3 Masticatory system disorders

There are 3 categories of masticatory dysfunction according to Okeson (2008):

1) Dentition
2) Temporomandibular joints
3) Muscles

Etiology of the masticatory system disorders is multifactorial. The most common factors contributing to masticatory system disorders are: anatomical factors, traumatic factors, psychosocial factors, pathophysiological factors and general factors (Machoň, 2008).

Anatomical factors, such as structural incompatibility of the articular surfaces or unstable occlusion, lead to alteration of the neuromuscular setting, which causes muscle spasms, pain and microtraumatisation of the joint (degenerative changes).

There are two major types of *traumatic factors*: microtraumatisation and macrotraumtisation. Microtraumatisation is caused by repeated non-physiological movements or parafunctional activity (bruxism) and this can lead to longlasting increase of intraarticular pressure, disc impairment, adhesions etc. Microtraumatisation of the joint is always followed by protective co-contraction or even muscle spasms.

Macrotrauma is a visible impairment of the joint structures, mostly caused by hit or excessive force. The manifestation of the impairment can occur immediately or within couple of years.

Psychosocial factors, such as stress, are causing hyperactivity of the masticatory muscles, which leads to parafunctional activity and parafunctional activity leads to microtraumatisation of the joint (see above).

The most common *patophysiological factors* are systemic diseases (rheuma), vertebrogenic disorders, local factors associated with dentition and mastication function. All these factors lead to muscle hyperactivity and following patophysiological reactions.

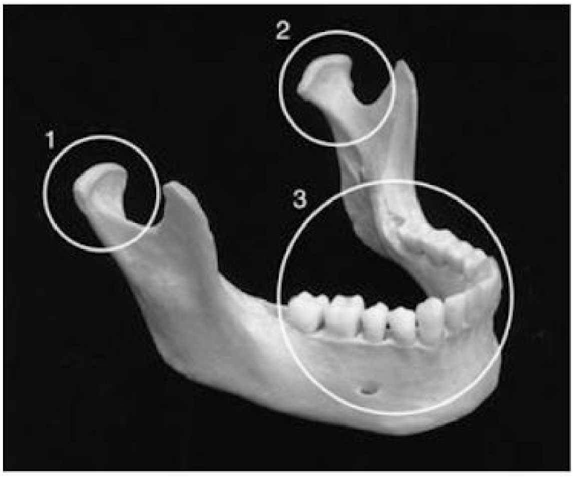
General factors are age and gender. Women are affected more often than men (3:1). The most frequently affected age group is between 20 and 40 years (Machoň, 2008).

2.1.4 Dentition

2.1.4.1 Defining optimum occlusion

The term occlusion means functional contact between maxillary teeth and mandibular teeth (Okeson, 2008). Optimum functional occlusion is described as an even and simultaneous contact of all possible teeth, when the mandibular condyles are in a musculoskeletally stable position *(Chapter 2.1.5.1)*.

This condition minimizes the force placed on each tooth during function (Okeson, 2008). In the picture below you can see the three areas of support on the mandible.



When the mandible is elevated, force is applied to the cranium in three areas: *(1 and 2)* the tempo ro mandibular joints and *(3)* the teeth.

Figure 3 Forces are applied to the cranium in 3 areas: temporomandibular joints (1, 2) and teeth (3), a picture from Okeson (2008)

2.1.4.2 Tooth position

The tooth position is influenced mainly by the opposing forces of surrounding musculature acting during and after eruption of the tooth. Lips and cheeks provide light constant lingually directed force and on the opposite side of the dental arches is the tongue (labially and buccally directed forces). Tooth stability is achieved when the opposing forces are in equilibrium. This state is called neutral position of the tooth (Okeson, 2008).

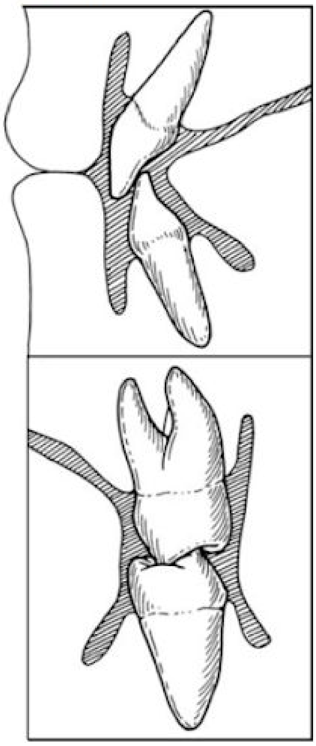


Figure 4 Neutral tooth position, a picture from Okeson (2008)

Okeson (2008) mentions the extreme importance of the *interarch* and *intraarch relationships* of the teeth, which can influence health and function of the masticatory system.

Here is an illustration how far is the *intraarch stability* important. Loss of a single tooth causes a chain of reactions: the opposing and adjoint teeth move to find lost stability and support, which leads to changes in the occlusal contacts and therefore changes of the whole masticatory system.

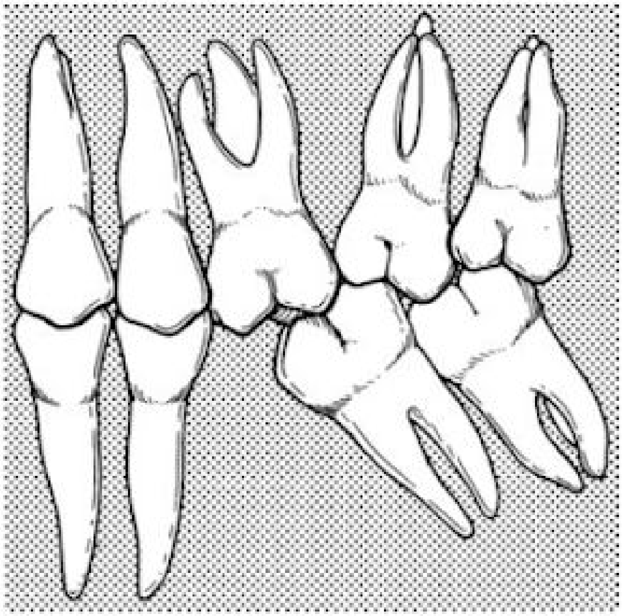


Figure 5 Consequences of tooth loss, a picture from Okeson (2008)

The interarch relationship is best described by **Angle class system**. This system classifies the occlusal relationships of the posterior teeth in 4 classes: *normal occlusion, class I, class II and class III malocclusion.*

Normal: The mesiobuccal cusp of the upper first molar aligns with the buccal groove of the mandibular first molar.

Class I: *Normal molar relationship*, but the other teeth have problems like spacing, crowding, etc.

Class II: The mesiobuccal cusp of the upper first molar is positioned *anteriorly* to the buccal groove of the mandibular first molar.

Class III: The mesiobuccal cusp of the upper molar is positioned *posteriorly* to the buccal groove of the mandibular first molar.

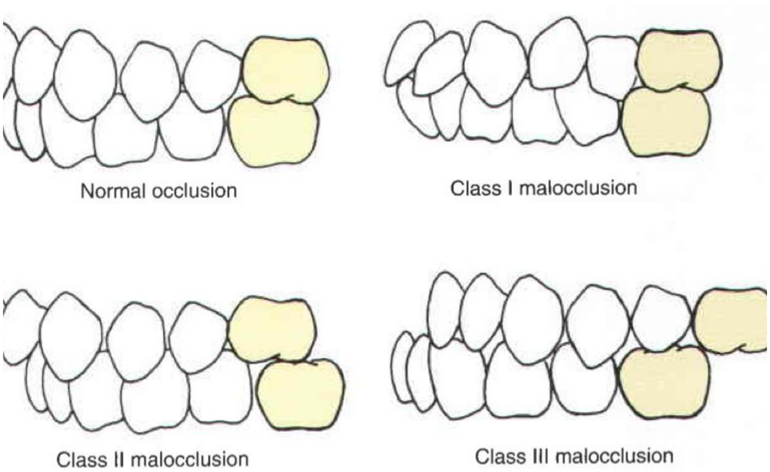


Figure 6 Angle class system, a picture from website: https://dentodontics.files.wordpress.com/2014/12/screen-shot-2011-07-09-at-10-41-222.png

2.1.4.3 Occlusion and muscle activity

It has been demonstrated in EMG studies, that all tooth contacts are by nature inhibitory. When the proprioceptors and nociceptors in the periodontal ligaments are stimulated, inhibitory responses are created and muscle activity is inhibited (Okeson in lecture for Post Grad. Students by Rahim).

The muscular control of mandibular position is strongly influenced by occlusal contact. “Unstable occlusion provokes the neuromuscular system to locate the mandible in a more stable occlusal condition” (Okeson, 2008).

Okeson (2008) speaks about reciprocal relationship between malocclusion and muscle function. Muscle dysfunction can cause malocclusion and reversely malocclusion causes muscle dysfunction.

2.1.4.4 Orthodontics and the masticatory system

Incidence of symptoms of temporomandibular disorders in population of orthodontically treated patients is no greater than that of the untreated general population (Okeson, 2008).

But any dental procedure that produces an occlusal condition that is not in harmony with the musculoskeletally stable position of the joint can predispose the patient to masticatory disorders (Okeson, 2008).

2.1.5 The temporomandibular joint

2.1.5.1 Musculoskeletally stable position

Every mobile joint has a musculoskeletally stable position. It is a state, when forces affecting the joint are equally distributed to the articular surfaces and cause minimal damage to the joint structures. The ligaments and the joint capsule are in minimal tension. This position allows ideal static loading of the joint (Kolář, 2010).

Concerning the TMJ we speak about centric relation. Centric relation is a position of the mandible, when the condyles are in the most superior and anterior position in the mandibular fossae with the articular discs properly interposed. This position allows maximum loading by the elevator muscles with no sign of discomfort (Veeraiyan, 2011).

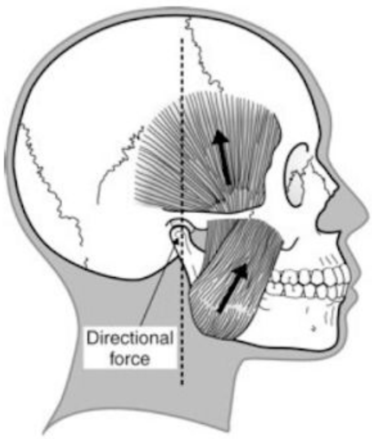


Figure 7 The directional forces of the levator muscles affecting the position of the TMJ, a picture from Okeson (2008)

The positional stability of any joint is determined by the directional force of the muscles that pull across the joint. Muscles stabilize joints (Okeson, 2008). As well Liebenson (2007) speaks about agonist-antagonist coactivation that helps to maintain functional joint centration. This mild state of contraction is called tonus (Okeson, 2008).

Increased muscle activity causes increase in interarticular pressure. Absence of muscle activity and interarticular pressure can lead to dislocation of the joint.

Masticatory muscles function more harmoniously and with less intensity when the temporomandibular joints are in centric relation position and the teeth are in maximum intercuspation (Okeson, 2008).

2.1.5.2 Effects of occlusal factors on orthopaedic stability

Orthopaedic stability of the masticatory system exists, when there is harmony between balanced intercuspal position and a musculoskeletally stable position of the TMJ. The situation, when the intercuspal position and the musculoskeletally stable position are different, is called orthopaedic instability of the masticatory system. When the teeth are not in occlusion, the musculoskeletally stable position is maintained by activity of the elevator muscles, so the occlusion does not have any influence on stability of the segment. Nevertheless, in occlusion, there is only one-tooth contact possible, which leads to unstable occlusal position. The musculoskeletally stable positions of the TMJs are maintained (Okeson, 2008).

However, the priority of the masticatory system is **occlusal stability** and thus the mandible is shifted to position with maximal occlusal contact (Okeson, 2008). In this situation the teeth are in a stable position for loading, but the TMJs are not.

2.1.5.3 Temporomandibular disorders

There are 2 major symptoms of the temporomandibular disorders: PAIN and DYSFUNCTION (Okeson, 2008).

Joint pain (arthralgia) originate from nociceptors located in the soft tissues surrounding the joint, because the articular surfaces have no innervation. The soft tissues surrounding the joint are following: discal ligaments, capsular ligaments and retrodiscal tissues (Okeson, 2008).

When elongation of the ligaments or compression of the retrodiscal tissue appears, nociceptors send out signals to the CNS. When the brain gets information about PAIN, it activates the protective co-contraction of the surrounding muscles, which leads to limited movement of the mandible. Limited movement of the mandible is a sign of DYSFUNCTION (Okeson, 2008).

Joint dysfunction is sometimes accompanied with joint sounds. Clicking sound indicates disc dislocation and crepitation is a sign of degenerative changes of the articular surfaces (Šebek, 2018).

2.1.6 Masticatory muscles

2.1.6.1 Masticatory muscles fibre type

Masticatory muscles are composed of different combinations of fiber types (Korfage et al., 2005). In jaw-closing muscles are dominantly expressed the slow twitch muscle fibers (type I) and therefore the jaw-closing muscles seem more adapted to perform slow, tonic movements. Jaw-opening muscles are more likely composed of the fast twitch muscle fibers (type II) and seem to be more adapted to produce faster, phasic movements.

Sciote et al (2012) published research comparing fiber type of subjects with physiological occlusion to subjects with malocclusion. Significant differences were found in subjects with vertical malocclusion, no differences were found for sagittal malocclusion groups.

2.1.6.2 Stages and pathophysiological principles of masticatory muscle disorders

a. Protective co-contraction (muscle splinting)
b. Local muscle soreness
c. Centrally influenced musle pain
d. Myofascial pain (TrPs)
e. Myospasm

When an event (for example: chewing unusually hard food, opening too wide, long dental procedure, source of constant deep pain etc.) disturbs normal muscle function, **protective co-contraction** appears. It is a CNS induced activation of antagonistic muscle groups aimed to protect the injured part. The symptom, which we can see, is limited mouth opening. Protective co-contraction resolves quickly, if the event subsides.

Prolonged co-contraction leads to local biochemical and structural changes in the muscle tissue, which is called **local muscle soreness**. Pain is experienced due to changes in the local release of certain algogenic substances. Local muscle soreness resolves spontaneously with rest or may need the assistance of treatment.

Local muscle soreness can also develop by local tissue injury (local anesthetic injection, tissue strain), unaccustomed use (chewing of gum) or as a referred pain from other areas (for example trapezius muscle).

If local muscles soreness doesn't resolve, the CNS enters the game and we have a **CNS-influenced muscle pain** disorder. Activity within the CNS can either influence or actually be the origin of muscle pain (Okeson, 2008).

Myofascial pain is a regional pain condition arising from hypersensitive areas in the muscles called trigger points. Trigger points are sources of constant deep pain and can produce central excitatory effects. They are also responsible for referred pain in predictable patterns according to localisation of the trigger point. These patterns are well described by Travell & Simons (1999).

Myospasms are not common, but when present, they are easily identified, because they create acute malocclusion.

2.1.6.3 Cyclic muscle pain and systemic factors

Local muscle soreness is a source of deep pain, which leads to protective co-contraction (Schwartz, 1956). This chain reaction is called cyclic muscle pain.

Any muscle pain is potentiated or even can be caused by systemic factors like emotional stress, acute illness or viral infections, constitutional factors, autonomic balance and immunologic resistence. (Okeson, 2008)

The emotional stress is tied with **hypertonus of the masticatory muscles**, because there is an incereased gamma efferent activity, which results in partial stretching of the muscle spindles and then increased sensitivity to external stimuli (Okeson, 2008).

2.1.6.4 Regulation of muscle activity

The contraction or inhibition of the masticatory muscles is a result of the combined output from gamma efferents, spindle efferents and alfa motoneurons. There is a continuous feedback information from the sensory receptors (periodontal ligaments, periosteum, TMJs, tongue etc), which is processed and the muscles are then directed to avoid noxious stimuli and thus **prevent damage or injury to the structures** (Okeson, 2008).

2.2 Posture

2.2.1 What is a posture

The postural function is responsible for maintaining and setting of particular segments, but also of the whole-body system in the gravitation field. This function is automatic, controlled by the multisensory afference (proprioception, exteroception, interoception, nociception) and will (Véle, 1997).

2.2.2 Factors that influence posture

The key factors influencing body posture are muscle tone, actual state of ligaments, anatomical conditions and especially central control mechanisms. Psychological state of the patient or pathology of the inner structures also show up in posture. Postural assessment leads to better understanding of the propensity of the patient to overloading or injury and builds a link between structure and movement function (Kolář, 2009).

Changes in posture can be secondary due to structural malformation, joint degeneration, joint instability, insufficient function of the ligaments, poor alignment of the body, pain etc. (Gross, Fetto, Rosen; 2002).

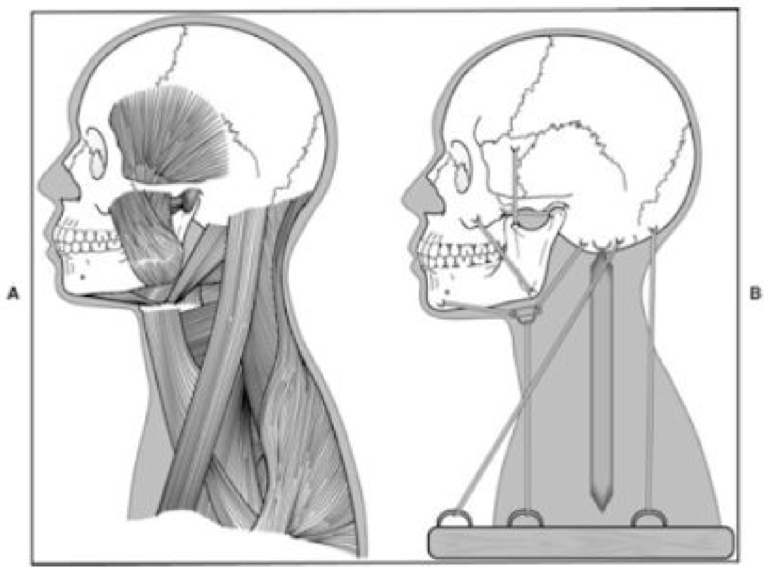
Poor pattern of stabilisation is easily fixed in the CNS, since stabilization is an automatic and subconscious function. Abnormal stabilization is then integrated into any movement compromising the quality of movement stereotypes and resulting in overloading, which can cause movement disturbances and pain syndromes (Liebenson, 2007).

2.2.3 Head position

The head has biomechanically tendencies to fall forward, because of the centroid in cella turcica. There has to be a constant activity of the suboccipital muscles to maintain upright head position (Véle, 1997).

The phenomenon called reciprocal innervation is responsible for smooth and exact control of the mandibular movement. Each of the antagonistic muscle groups remains in a constant state of mild contraction – tone. The muscle activity enables the postural positioning of the head against gravity and plays an important role in the mandibular rest position. (Okeson, 2008)

Fig. 2-1



Precise and complex balance of the head and neck muscles must exist to maintain proper head position and function. **A**, Muscle system. **B**, Each of the major muscles acts like an elastic band. The tension provided must precisely contribute to the balance that maintains the desired head position. If one elastic band breaks, the balance of the entire system is disrupted and the head position altered.

Figure 8 A balanced system of the head and neck muscles, a picture from Okeson (2008)

2.2.4 Spinal curves

The spine has two S-type curves in the sagittal plane (Kolář, 2009). There are two forward convexities - cervical lordosis and lumbar lordosis – and two backward convexities: thoracic kyphosis and sacral kyphosis (Hudák et Kachlík, 2013).

The curvature in the frontal plane is called scoliosis. There are two types of scoliotic curve: "C-type" and "S-type" (Hudák et Kachlík, 2013). The severity of scoliosis is measured by Cobb's angle. A patient is classified with scoliosis, if the Cobb's angle is greater than 10° according to Scoliosis research society.

The spinal curves are created by directional forces of the neck and back muscles, influence has also the weight of body organs and the variance between the front and back margin of each vertebra (Kolář, 2009).

2.3 Approaches in physiotherapy dealing with referred pain and kinetic chains

2.3.1 Segmental model of the locomotor system

To simplify understanding of the human body, we can see it as a set of segments, that are interconnected by joints. One segment is a compact, homogenous and undeformable part joined to other segments. The segments build a lever system, which is influenced by inner forces (muscles) and outer forces (gravitation, momentum). These forces induce movement of the segments and movement of the whole-body system (Vařeka, 1997).

2.3.2 Structural and functional disorders

Lewit (2000) states, that a primary structural lesion has its functional component, which can be treated by different approaches, for example manual medicine, physical therapy, kinesiotherapy etc. Functional disorders have clear pathophysiological mechanisms of which the most important are reversibility and chaining to other segments. If the functional disorder persists for longer time period, it is a sign of suppression or wrong mechanism of auto-reparation (Poděbradský et Poděbradská, 2009). Wrong auto-reparative mechanism leads to immoderate correction in other segments and the sequels can be much more severe than the primary disorder.

For our purposes, malocclusion may be a primary structural lesion followed by protective co-contraction of the masticatory muscles, which is a functional component of the structural disorder. When protective co-contraction is not resolved, local muscle soreness and myofascial pain occurs with common consequences.

2.3.3 Referred pain, difference between source and site of pain

The source and site of pain are not the same terms. The site of pain means the location, where the patient describes feeling it. The source of pain goes to the origin of the pain. Primary pain is a term used when the site and source of the pain are in the same location (Okeson, 2008).

When the site and source are in different locations, we speak about heterotopic pain (Okeson, 2008). There are more types of heterotopic pain, but for purposes of this study is of major importance the referred pain.

Travell & Simons (1999) defines referred pain as a pain arising in the trigger point, but felt at a distance, often entirely remote from the source. The distribution of the pain does not coincide with a peripheral nerve or dermatome segment, it occurs in specific patterns of referred pain.

The referred pain in the trigeminal area never crosses the midline unless it originates at the midline. For example, pain of the left TMJ never causes pain in right masticatory muscles. This rule does not work in the lower segments such as in the cervical region. (Okeson, 2008)

Okeson (2008) mentions two rules to remember:

- The treatment must be directed on the source, not the site of the pain to achieve effective results. Primary pain is easy to deal with, because the site and the source of the pain are the same. A common mistake is made when dealing with heterotopic pain. Treating the site, not the source of the pain will always fail to resolve the pain problem.
- Second rule is addressing the differentiation between the source and site of the pain. Local provocation of the source will cause an increase in symptoms, however local provocation of the site will generally not increase symptoms. If a patient has source of pain in the temporomandibular joint, mouth opening will accentuate pain. If the source of pain is in the cervical region and in the

TMJ is only referred pain, the mouth opening will not provoke more pain. Pain felt in the masticatory structures that is not accentuated by jaw function is suspicious and possibly not originating in the masticatory system.

2.3.4 Chain reactions in the locomotor system

The concept of kinetic chains was introduced by Franz Reuleaux, a mechanical engineer, in 1875 (Ellenbecker et Davies, 2001). He proposed that rigid, overlapping segments were connected via joints and this created a system whereby movement at one joint produced or affected movement of another joint in the kinetic link.

1) Mechanistic approach

The mechanistic approach is based on anatomical and biomechanical principles (Vařeka et Dvořák, 2001). The main protagonists of this approach are Travell, Mezier, Mojžíšová, Brunkow and others.

It is about clearly defined muscle-tendon chains, but limitation is, that the controlling mechanisms of the CNS are not considered. It is sometimes difficult to find direct anatomical connections between distant anatomical regions. There are two typical phenomenons difficult to explain when not considering the controlling mechanisms of CNS: (1) skipping of particular segments of the chain, (2) localisation of the maximal functional disorder, manifesting with pain, in another segment than the one with primary lesion (Vařeka et Dvořák, 2001).

2) Cybernetic approach

The locomotor system is controlled by CNS and endocrine system. The controlling system uses specific motor programs to reach the demanded aim. If one part of the locomotor system is weakened or totally off the function, the controlling system uses another track to reach the primal goal. Mostly the substitutional and compensational mechanisms have to be used (Vařeka et Dvořák, 2001).

Thus, the human body is functional even if there is an impairment in one or more segments, but the more load is given to the remaining segments and therefore are the remaining segments predisposed to overload or injury (Vařeka et Dvořák, 2001).

The key stone in cybernetic approach is the afference from periphery to CNS and of course the motor programs, which contain also the setting and maintaining of posture. Posture is understood as an active body alignment controlled by CNS and realized by locomotor system with limitation of given anatomical and biomechanical conditions of each subject (Vařeka et Dvořák, 2001).

3) Postural model of chain reactions in the locomotor system

The postural model combines both approaches, importance is given to anatomical and biomechanical conditions, but also the controlling function of CNS is included (Vařeka et Dvořák, 2001).

Posture is maintained by inner forces of the muscles controlled by CNS and optimal posture contains two aspects: straightened spine and stabilized trunk (Vařeka et Dvořák, 2001). Of great importance are considered by almost all members of Prague school (Lewit, Janda, Véle, Kolář) following muscle groups: the autochthonous musculature, deep neck flexors, abdominal wall, diaphragm and the pelvic floor.

2.3.5 Chaining of the disorders – generalisation

Poděbradský and Poděbradská (2009) speak about two main types of generalisation: vertical generalisation and horizontal generalisation. Chaining of disorders following the line “CNS-spinal cord-muscles-joints-skin” is called vertical generalisation. For example, a joint blockade induces reflex muscle spasms. Changed afferentation results in modification of the muscle tone and changed body posture. Horizontal generalisation describes "one-level-chaining". Joint blockade causes another joint blockade in associated segments (according to Lewit), myofascial pain causes another myofascial pain (according to Véle), trigger point in one muscle leads to trigger points in referred muscles (according to Travell & Simons).

3 AIMS AND HYPOTHESES

3.1 Aims

It is a screening study of relationships tying parameters from the orofacial area and spinal parameters together with the aim of finding if there is any correlation between asymmetries and pathologies in the orofacial area and spine curvature disorders, resp. back pain.

3.2 Hypotheses

(1) There is a relationship between sagittal morphology of the face and spine curvature.

(2) Occlusion asymmetries are related to spinal deviations.

(3) Hypomobility of the TMJs is affecting the spine curvature.

(4) There is a relationship between asymmetric movement of the mandible and spinal deviations.

4 PRACTICAL PART

4.1 Methods

4.1.1 Subjects

24 volunteers participated in this study (2 males, 22 females). The age composition is shown in Table 1.

Table 1 Age composition

N	Valid	24
	Missing	0
Mean		21.54
Median		22.00
Std. Deviation		1.285
Minimum		18
Maximum		24

4.1.2 Measuring process

Study participants were invited to the examination room, where they filed in the questionnaire and underwent a clinical examination of the orofacial area and a rasterostereographic analysis of the spine using Diers formetric 4D. Each study participant has read and signed the informed consent.

4.1.3 Orofacial area, TMJ and occlusion

Specific parameters from the clinical examination were used to describe the orofacial area, temporomandibular joint and occlusion, and to identify functional and structural impairments and asymmetries.

The set of measured parameters origins in the anthropometric analysis of the orofacial area used by orthognathic surgeons. For our purposes, we added some special parameters and deleted parameters that were not relevant for our study.

4.1.3.1 Overjet and overbite

Overjet and overbite are numeric parameters showing the *sagittal inter-alignment* of the maxillary and mandibular front teeth. Physiological value of overjet and overbite is between 2 and 4 mm (Kinaan BK. 1986).

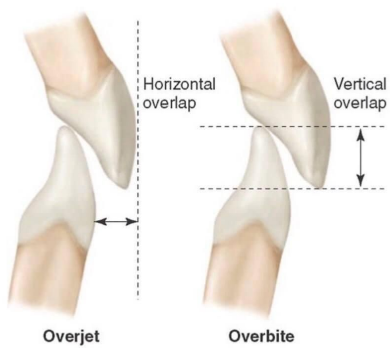
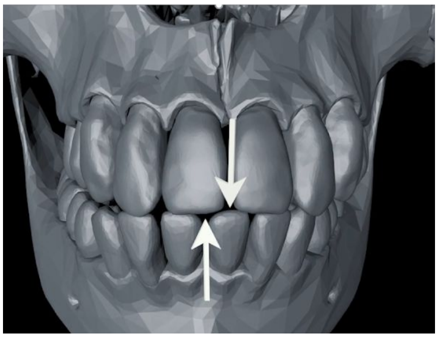


Figure 9 Overjet and overbite, a picture from website https://dentagama.com

4.1.3.2 Midline deviation

The shift of the teeth in dental arches describes **midline deviation**. The midline deviation is measured towards the midline of the face.



4.1.3.3 Occlusal plane

The occlusal plane was evaluated using the Fox's bite plane. There are 3 major types of occlusal plane compared to interpupillary line: parallel, left descent, right descent.

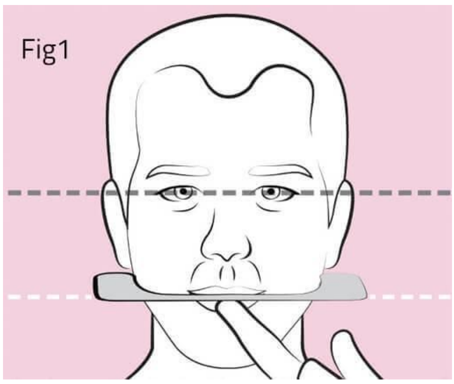


Figure 10 The occlusal plane, a picture from website http://www.astekinnovations.com

4.1.3.4 Rotation of the upper and lower jaw

The last parameter used to describe the interalignment of maxilla and mandible was the **rotation**, i.e. deviation in the transversal plane. There were 3 possible options: normal, rotated to the left (anti-clockwise), rotated to the right (clockwise).

4.1.3.5 Other

Teeth abrasion, occlusion types, head position, face profile and chin symmetry were measured, but not evaluated due to lack of prevalence of all types in the study group.

<u>CLINICAL EXAMINATION OF THE TEMPOROMANDIBULAR JOINT</u> consists of ROM (range of movement) measurements and of evaluating the movement trajectory (symmetric/asymmetric).

The mandibular movement is greatly influenced by the muscle activity. Bilateral tense muscles cause restriction of movement, unilateral muscle tension leads to movement asymmetry.

4.1.3.6 Mandibular movement parameters

2 tests were used to evaluate the range of movement in the TMJ. That are: mouth opening test and protrusion test.

Mouth opening test:

We asked the patient to open mouth to the maximum and then we have measured a distance between maxillary and mandibular incisors. The distance is measured in millimetres (mm). Okeson (2008) describes the normal range of mouth opening as 53-58 mm. When the distance is less than 40 mm, we speak about restricted range of movement in the temporomandibular joint. The causes of restricted movement are divided into two subgroups: extracapsular and intracapsular. Extracapsular restrictions occur when the masticatory muscles are tight bilaterally or when *masticatory muscle pain* is limiting the movement. When there is *bilateral temporomandibular joint disorder* causing joint hypomobility, we speak about intracapsular disorder.

Fig. 9-20 MEASURING MOUTH OPENING.

Figure 11 Measuring of mouth opening, picture from Okeson (2008)

Mandibular protrusion test:

Protrusion is a maximum forward movement of the mandible. We have measured the distance (in mm) between maxillary and mandibular incisors. Normal protrusion range of movement is 9-11 mm according to Machoň (2008). The causes of protrusive movement restrictions are similar as in mouth opening.

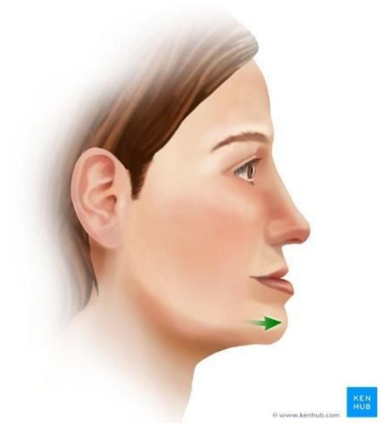


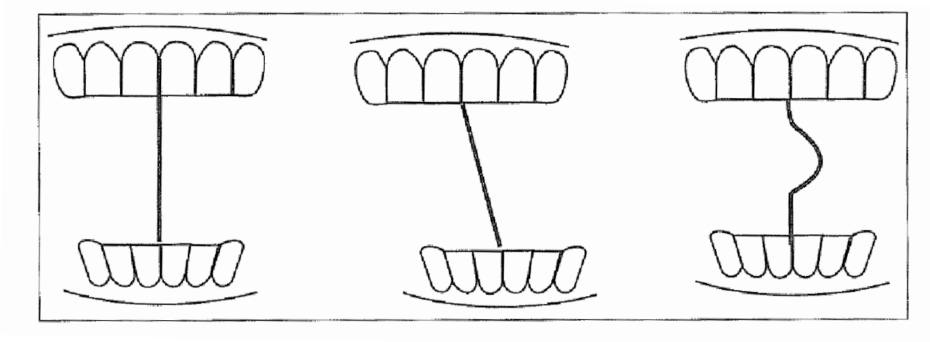
Figure 12 Protrusion test, a picture from website https://thumbor.kenhub.com

Mouth opening symmetry:

The trajectory drawn by the midline of the mandible was observed and compared to the axial line of the face. There are 3 possible trajectories of the mouth opening pathway. In a healthy masticatory system, there are no alterations – the trajectory goes parallel to the axial line of the face. The mandibular midline goes straight downward and *symmetrically*.

An arch-shaped curve is observed in subjects with *deviation* type of mouth opening. The mandible midline shifts during mouth opening to one side (left or right) and then returns back to the midline in the end of the movement. The most common cause is a disc derangement in one or both TMJs. The mandibular condyle has to get over the disc and then returns back.

Deflection is a shift of the mandible midline to one side (left or right) that becomes greater with opening and does not return back to the midline. Deflection is found in subjects with either restricted movement in one joint or when unilateral muscle tightness is present.



symmetrical *deflection* *deviation*

Figure 13 Mouth opening types, a picture from Machoň (2008)

Protrusion symmetry:

In subjects with healthy masticatory system goes the trajectory of the protrusive movement *straight forward*. Unilateral joint disorder or muscle tightness can cause alterations in the protrusive pathway – the end position is shifted *left* or *right*.

4.1.4 Measuring of the spinal curves using Diers formetric 4D

We used Diers formetric 4D to assess posture and spinal curves. It is a type of optical measurements called video rasterstereography. It is radiation-free and non-invasive.

Conditions: A subject stands on the platform with undressed upper body, hair tied up and with no bracelets, rings or wristwatch. The room is dark during the measurement, one

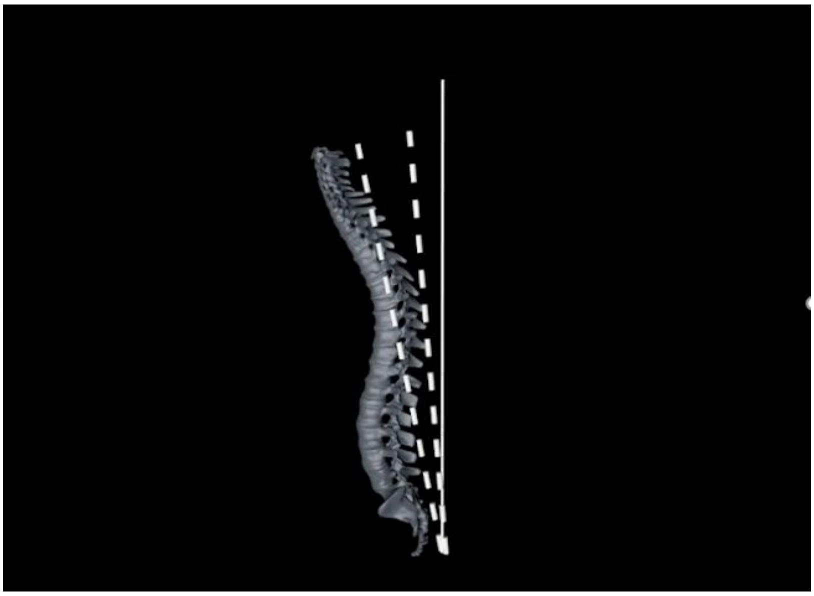
measurement takes approximately 6 seconds. All subjects were examined with the same device, in the same room and same conditions.

Principle: A line grid is projected on the back of the patient, the surface is then recorded by camera and analysed by computer. The computer software creates a tree-dimensional model of the spine.

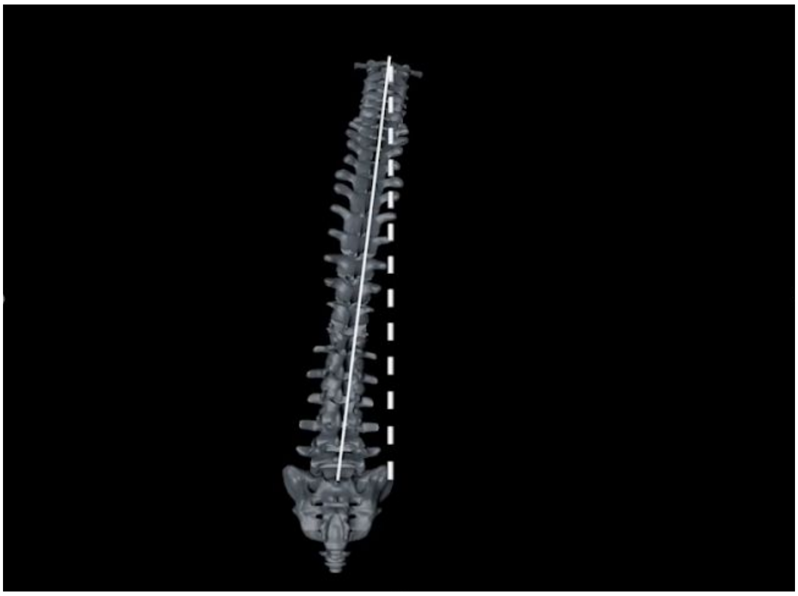
One formetric measurement comprises up to 85 values. We evaluated 9 of them.

4.1.4.1 Deviation of the trunk plumb line in the sagittal and frontal plane

Trunk inclination is the angle between the VP (vertebra prominens) plumb line and the VP-DM line (DM = middle point between lumbar dimples) in the lateral projection. Positive values indicate trunk inclination forwards, negative values indicate trunk inclination backwards. The measurement unit is degree (°).



Trunk imbalance is the angle between VP-DM line and the VP plumb line in the frontal projection. Positive values indicate trunk shift to the right, negative values indicate trunk shift to the left. The measurement unit is degree (°).



4.1.4.2 Spinal curves in the sagittal plane

To describe spinal curves in the sagittal plane we used maximum kyphotic angle and maximum lordotic angle.

Kyphotic angle is an angle between ICT surface tangent and ITL surface tangent. ICT is the inflexion point between cervical lordosis and thoracic kyphosis, ITL is the inflection point between thoracic kyphosis and lumbar lordosis. The measurement unit is degree (°).

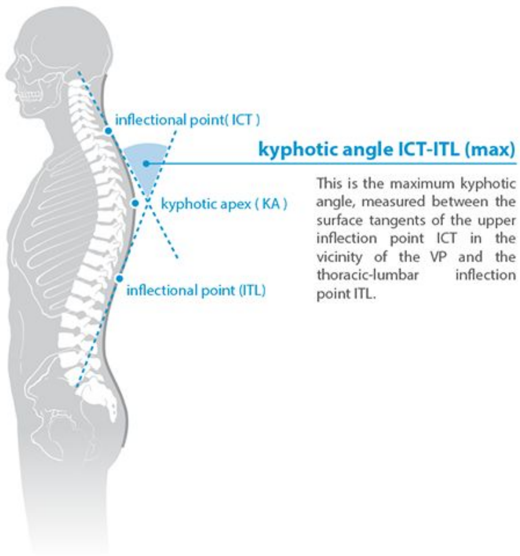


Figure 14 kyphotic angle, a picture from website https://diers.eu

Lordotic angle is an angle between ITL surface tangent and ILS surface tangent. ITL is the inflection point between thoracic kyphosis and lumbar lordosis, ILS is the inflection point between lumbar lordosis and sacrum. The measurement unit is degree (°).

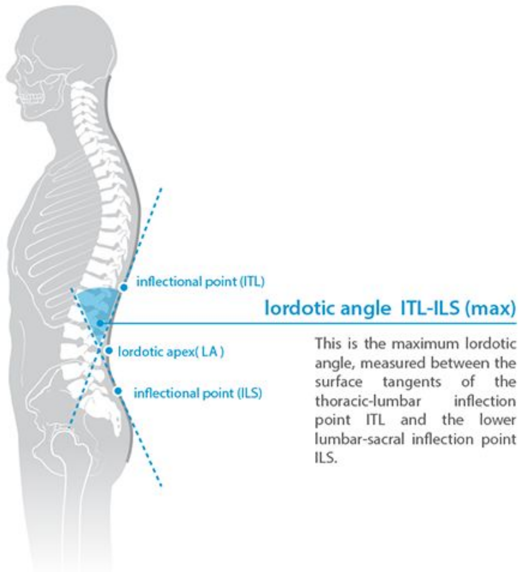


Figure 15 Lordotic angle, a picture from website https://diers.eu

Flèche cervicale is the distance between cervical apex and the tangent to kyphotic apex.

Flèche lombaire is the distance between lordotic apex and the tangent to kyphotic apex.

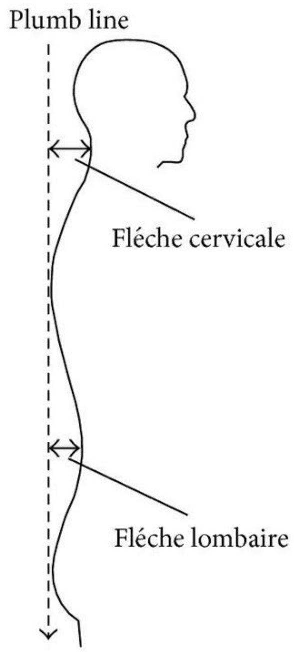
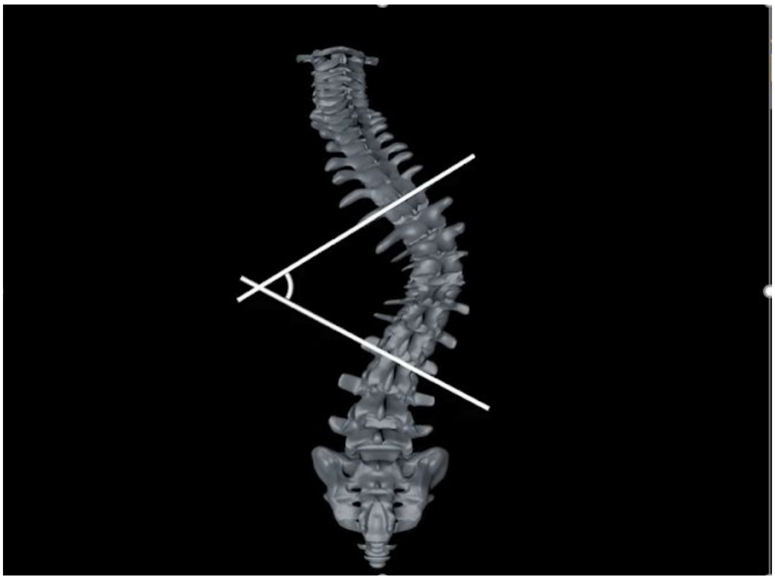


Figure 16 Fleche cervicale and fleche lombaire, a picture from website https://www.researchgate.net

4.1.4.3 Spine in the frontal plane

Cobb's angle: the computer software finds two end-vertebrae of the curve, which are the most tilted towards each other, draws lines going along and then the angle can be measured.

We also evaluated the thoracic and lumbar curve in the frontal plane of each subject using values "-1, 0, 1". Negative value describes curve to the left side bigger than 6 mm of apical deviation (apical deviation = distance of the vertebrae to the plumb line), "0" means physiological range of apical deviation, positive value describes curve to the right side bigger than 6 mm of apical deviation.



Amplitude of lateral deviations is a total distance (mm) between maximal spinal curve deviations (apical deviation) to the right plus maximal spinal curve deviations (apical deviation) to the left from the VP-DM line (virtual line between vertebra prominens (VP) and middle point (DM) between the right and left sacral dimples) in the frontal plane.

4.1.4.4 Transversal plane

A line is drawn between the centre of the vertebra and spinous process. This line makes an angle with the perpendicular line to the plum line going through the centre of the vertebra. The computer software evaluates all vertebrae of the thoracic and lumbar spine. In results we see the **maximal vertebral rotation (max)** and **mean vertebral rotation (rms)**. Vertebral rotation RMS is a root mean square of the vertebral rotation (°) along the longitudinal axis of the spine. Ideal value for vertebral rotation is 0°.

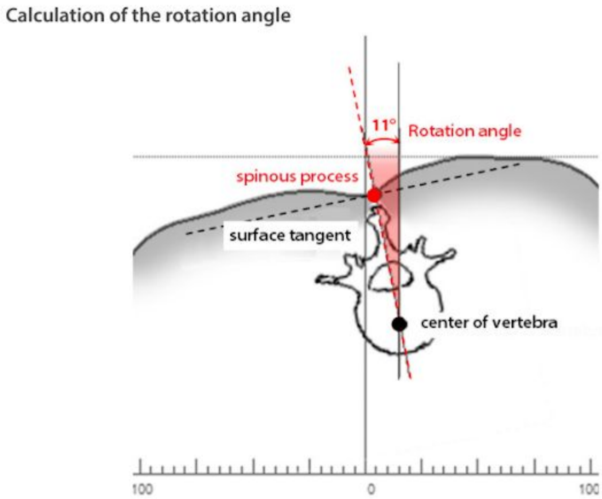


Figure 17 Vertebral rotation, a picture from Diers Manual Results

4.1.5 **Statistical analysis**

For statistical analysis IBM SPSS Statistics 23 (IBM corporation, USA) software was used. Because of small group sizes and also not normally distributed data, non-parametric tests were used. When looking for differences between two independent groups, Mann Whitney U test was used. When looking for correlation between two numerical variables, Spearman's rank-order correlation test was performed.

4.2 Results

4.2.1 Results of the orofacial examination (orofacial parameters)

4.2.1.1 Occlusal parameters in static position

The descriptive statistics of the numerical parameters are summarized in Table 2. The results of the occlusal plane parameter, which is a categorical parameter and thus virtually divides our sample into 3 groups; with parallel occlusal plane, with right descend or left descend, are presented in Table 3.

Table 2 Descriptive statistics of the occlusal parameters in static position.

	N	Mean	Median	Std. Deviation	Minimum	Maximum
Mandibular midline deviation (mm)	24	.0217	.0000	1.48077	-3.00	3.00
Maxillary midline deviation (mm)	24	-.0208	.0000	1.31446	-3.00	2.00
Overjet (mm)	24	3.9375	4.0000	1.28801	2.00	6.00
Overbite (mm)	24	2.9375	3.0000	1.54154	.00	8.00

Table 3 Occlusal plane parameter. Numbers represent counts of individuals with either parallel occlusion, or with asymmetrical occlusion with right or left descend.

	Total N	Right descend	Left descend
Parallel occlusal plane	10	0	0
Asymmetrical occlusal plane	14	6	8

4.2.1.2 Mandibular movement parameters

The descriptive statistics of the numerical parameters are summarized in Table 4. The results of the mouth opening symmetry (categorical value) are presented in Table 5. Note that although we subdivide the mandibular deviations and deflections into “To right” or “To left” subgroups in the Table 5, in further statistical analysis of possible relationships between parameters we only use the total asymmetry numbers (Total N) for mandibular deflections and deviations.

Table 4 Descriptive statistics of the mandibular movement parameters.

	N	Mean	Median	Std. Deviation	Minimum	Maximum
Mandibular protrusion test (mm)	24	7.02	7.75	2.644	1	12
Mouth opening test (mm)	24	47.88	48.50	5.327	33	58

Table 5 Mouth opening symmetry parameter. Numbers represent counts of individuals either with symmetrical opening, or with mandibular deviation of deflection. Moreover, the asymmetrical groups are still subdivided into "To left" or "To right" subgroup.

	Total N	To right	To left
Symmetrical opening	5	0	0
Mandibular deviation	10	9	1
Mandibular deflection	9	6	3

4.2.2 Results of the spinal Diers formetric 4D examination (spinal parameters)

The descriptive statistics of the numerical spinal parameters are summarized in Table 6.

Table 6 Descriptive statistics of the spinal parameters obtained from the Diers formetric 4D examination.

	N	Mean	Median	Std. Deviation	Minimum	Maximum
Amplitude of lateral deviations (mm)	24	12.7817	10.8150	7.48278	5.32	32.85
Fléche cervicale (mm)	24	42.06	40.84	13.906	14	68
Fléche lombaire (mm)	24	48.93	47.87	12.506	27	74
Kyphotic angle (°)	24	44.0950	43.0500	9.04730	28.86	60.46
Lordotic angle (°)	24	43.1404	43.7750	8.56899	20.70	64.68
Scoliosis angle (°)	24	13.67	12.50	6.176	5	27
Trunk inclination (°)	24	-.68208	-.48000	1.969134	-3.890	3.010
Trunk imbalance (°)	24	-.18000	.00000	1.405727	-3.320	2.140
Vertebral rotation MAX (°)	24	1.1433	3.9300	7.23398	-13.45	10.95
Vertebral rotation RMS (°)	24	3.4183	3.1050	1.36107	1.45	5.90

4.2.3 Results of the statistical analysis of possible relationships between the orofacial and spinal parameters

In general, to reveal possible relationships between parameters from the orofacial and spinal region Spearman's rank-order correlation (for testing strength and direction of association between two numerical variables) or Mann-Whitney U test (for testing significant differences in one numerical variable between two independent groups) was performed.

Primarily we looked for the possible relationships between occlusal parameters in static position and spinal parameters; nonetheless statistical analysis did not reveal any relationships between these parameters (statistical data not shown; cells with yellow background in Table 7 visually summarize these results).

Thus, we focused on the mandibular movement parameters and their possible relation with spinal parameters. Results of the Spearman's correlation test indicated no significant association between mandibular protrusion test (mm) and any of the spinal parameters (Figure 18,

Table **7** visually summarizes these results).

Analogical situation was with relations between mouth opening test (mm) and spinal parameters; Spearman's correlation test did not indicate any association between these parameters (statistical data not shown,

Table **7** visually summarizes these results).

In contrast to the two previous mandibular movement parameters, where correlation studies between different numerical variables could be performed, in case of mouth opening symmetry parameter, which is a categorical variable that divided our sample into 3 groups (symmetrical, mandibular deviation, mandibular deflection), a Mann-Whitney U test was used to find statistically significant differences between two groups (all combinations of these 3 opening mouth symmetry groups were tested) in any of the spinal parameters. After evaluating all the possible combinations, statistical analysis pointed out 4 spinal parameters; namely the amplitude of lateral deviations (mm), the fléche lombaire (mm), the scoliosis angle (°) and the vertebral rotation RMS (°) parameter, in which at least one combination of the three groups came out significantly different (

Table **7**).

In case of amplitude of lateral deviations Mann-Whitney U test showed, that individuals with mandibular deflection *(Mdn = 13.16)* have significantly larger amplitude then individual with symmetrical mouth opening *(Mdn = 7.44), U = 6.000, p = .028, r = 0.588*, (Figure 19).

In terms of fléche lombaire, individuals with symmetrical mouth opening *(Mdn = 58.90)* had significantly larger value then individuals with mandibular deflection *(Mdn = 43.91), U = 5, p = .02, r = 0.624*, (Figure 20).

When comparing scoliosis angle, the individuals with mandibular deflection *(Mdn = 15)* had significantly higher scoliosis angle then individuals with symmetrical mouth opening *(Mdn = 10), U = 7, p = .037, r = 0.557*, (Figure 21).

In case of vertebral rotation RMS parameter, not only that individuals with mandibular deflection *(Mdn = 4.39)* had significantly higher degrees then individuals with symmetrical mouth opening *(Mdn = 2.22), U = 6, p = .028, r = 0.588*, but also individuals with mandibular deviation *(Mdn = 3.40)* had significantly higher values then the group with symmetrical mouth opening *(Mdn = 2.22), U = 6.5, p = .023, r = 0.586*, (Figure 22).

Table 7 Visual summary of relationships between orofacial parameters (columns) and spinal parameters (rows). Yellow background highlights occlusion parameters in static position, green background highlights mandibular movement parameters. Plus (+) sign depicts significant relationships between the particular parameters. Minus (-) sign designates no relationships between the particular parameters.

	Occlusal plane (Categorical variable)	Mandibular midline deviation (mm)	Maxillary midline deviation (mm)	Overjet (mm)	Overbite (mm)	Mandibular protrusion test (mm)	Mouth opening test (mm)	Mouth opening symmetry (Categorical variable)
Amplitude of lateral deviations (mm)	-	-	-	-	-	-	-	+
Fléche cervicale (mm)	-	-	-	-	-	-	-	-
Fléche lombaire (mm)	-	-	-	-	-	-	-	+
Kyphotic angle (°)	-	-	-	-	-	-	-	-
Lordotic angle (°)	-	-	-	-	-	-	-	-
Scoliosis angle (°)	-	-	-	-	-	-	-	+
Trunk inclination (°)	-	-	-	-	-	-	-	-
Trunk imbalance (°)	-	-	-	-	-	-	-	-
Vertebral rotation MAX (°)	-	-	-	-	-	-	-	-
Vertebral rotation RMS (°)	-	-	-	-	-	-	-	+

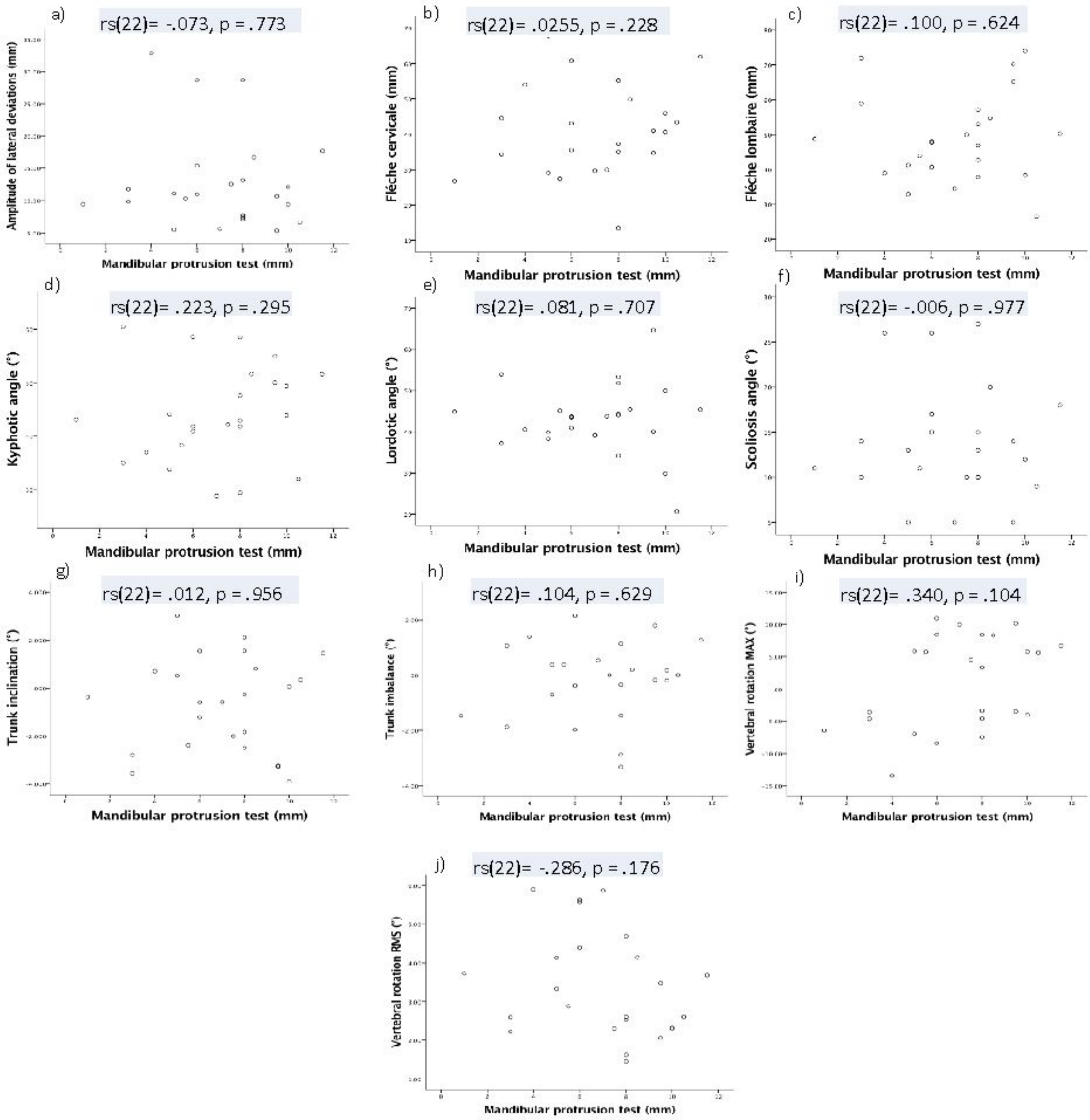


Figure 18 **No** significant (p > 0.05) correlation was found between mandibular protrusion test (mm) and a) amplitude of lateral deviations (mm), b) fléche cervicale (mm), c) fléche lombaire (mm), d) kyphotic angle (°), e) lordotic angle (°), f) scoliosis angle (°), g) trunk inclination (°), h) trunk imbalance (°), i) vertebral rotation MAX (°) and j) vertebral rotation RMS (°). Each circle represents a single individual (N = 24).

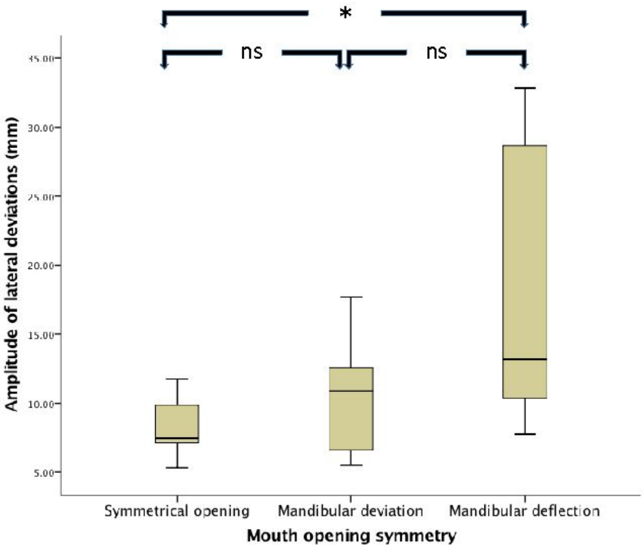


Figure 19 Relationship between mouth opening symmetry and amplitude of lateral deviations of the spine (mm). Box plots represent amplitude of the lateral deviations in group with symmetrical mouth opening (N = 5), in group with mandibular deviation (N = 10) and in group with mandibular deflection (N = 9). The bold horizontal line within the box represents median. Upper and lower lines of the box represent 25th and 75th percentile, upper and lower whisker represent 1,5xIQR, circles falling outside the whisker range represent outliers. **Asterisks** denotes significant difference between particular groups, $p < 0.05$. The not significant differences between particular groups, $p > 0.05$, are denoted as **ns**.

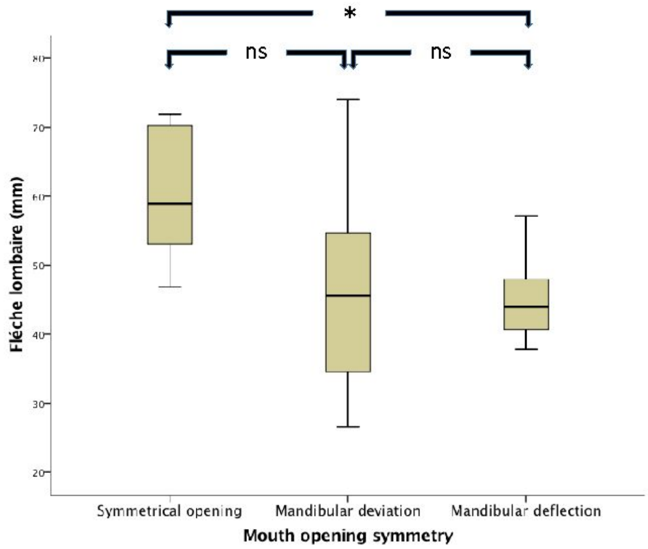


Figure 20 Relationship between mouth opening symmetry and fléche lombaire (mm). Box plots represent fléche lombaire in group with symmetrical mouth opening (N = 5), in group with mandibular deviation (N = 10) and in group with mandibular deflection (N = 9). The bold horizontal line within the box represents median. Upper and lower lines of the box represent 25th and 75th percentile, upper and lower whisker represent 1,5xIQR, circles falling outside the whisker range represent outliers. **Asterisks** denotes significant difference between particular groups, $p < 0.05$. The not significant differences between particular groups, $p > 0.05$, are denoted as **ns**.

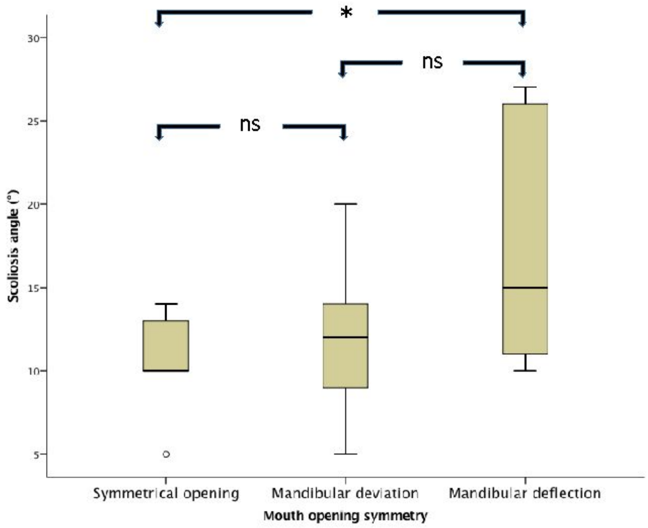


Figure 21 Relationship between mouth opening symmetry and scoliosis angle (°). Box plots represent scoliosis angle in group with symmetrical mouth opening (N = 5), in group with mandibular deviation (N = 10) and in group with mandibular deflection (N = 9). The bold horizontal line within the box represents median. Upper and lower lines of the box represent 25th and 75th percentile, upper and lower whisker represent 1,5xIQR, circles falling outside the whisker range represent outliers. **Asterisks** denotes significant difference between particular groups, $p < 0.05$. The not significant differences between particular groups, $p > 0.05$, are denoted as **ns**.

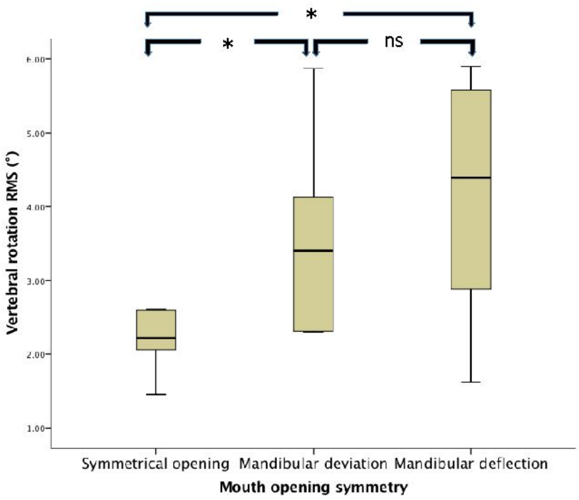


Figure 22 Relationship between mouth opening symmetry and vertebral rotation RMS (°). Box plots represent vertebral rotation RMS in group with symmetrical mouth opening (N = 5), in group with mandibular deviation (N = 10) and in group with mandibular deflection (N = 9). The bold horizontal line within the box represents median. Upper and lower lines of the box represent 25th and 75th percentile, upper and lower whisker represent 1,5xIQR, circles falling outside the whisker range represent outliers. **Asterisks** denotes significant difference between particular groups, $p < 0.05$. The not significant differences between particular groups, $p > 0.05$, are denoted as **ns**.

4.3 Discussion

One of our hypotheses (1) was aimed to follow the results of D'Attilio et al. (2005) who tested a relationship between sagittal morphology of the face and cervical spine. Their findings suggest higher extension of cervical lordosis in subjects with Angle Class II malocclusion and lower cervical lordosis in subjects with Angle Class III malocclusion. We used different parameters to assess the sagittal morphology of the face – overjet and overbite – clear numerical values representing the interrelationship between the incisors of maxilla and mandible. High values of overjet/overbite correspond with Angle Class II and low values correspond with Angle Class III. We wanted to find out, if the sagittal morphology of the face is related to lower parts of the spine – kyphotic and lordotic angle. However, our results do not support this hypothesis. No significant relationships were found between overjet/overbite and the curvature of the spine.

There is no published study addressing the relationship between the midline deviation and spine curvature. Our results however showed no significant correlation to any parameter of the spine curvature (amplitude of lateral deviation, fléche cervicale, fléche lombaire, kyphotic angle, lordotic angle, scoliosis angle, trunk inclination, trunk imbalance, vertebral rotation MAX, vertebral rotation RMS).

The occlusal plane did not show any connection to spinal curves either.

We can thus sum up, that asymmetries in occlusion such as shift of the dental arch midline or oblique occlusal plane are not correlated to the spine curvature.

There are lots of studies dealing with the relationship between temporomandibular disorders and scoliosis. The temporomandibular disorders are manifesting with pain and dysfunction (hypomobility). We addressed first the relationship between range of movement (ROM) in the TMJ and scoliosis. Not one of the ROM tests (mouth opening, protrusion test) showed correlation with scoliosis angle and also with no other measured parameters of the spine (amplitude of lateral deviation, fléche cervicale, fléche lombaire, kyphotic angle, lordotic angle, trunk inclination, trunk imbalance, vertebral rotation max, vertebral rotation rms).

If there is unilateral TMJ dysfunction or articular disc dislocation, asymmetric mouth opening pathway occurs. We wanted to find out, if asymmetry of this frequently repeated movement (up to 1800 times a day according to Harrison 1997) is manifested somehow in the curvature of the spine. And finally, our results support this hypothesis. A statistically significant differences of the spine curvature (scoliosis angle, vertebral rotation RMS, amplitude of lateral deviation) were found between subjects with symmetrical mouth opening type compared to subjects with deflection mouth opening type.

A little surprising relationship was found between mouth opening type and fléche lombaire. Subjects with symmetrical mouth opening type have higher values of fléche lombaire compared to subjects with deflection mouth opening type. We do not have any explanation for this relationship at the moment, it has to be further investigated.

In this study we have shown, that there are some significant connections between asymmetries in the orofacial area and spinal curves. Three most important results are (1) subjects with asymmetric mouth opening have higher values of scoliosis angle compared to subjects with symmetric mouth opening; (2) subjects with asymmetric mouth opening have higher values of vertebral rotation RMS compared to subjects with symmetric mouth opening; (3) subjects with asymmetric mouth opening have higher values of amplitude of lateral deviation of the vertebrae compared to subjects with symmetric mouth opening.

The relationship between occlusion and posture is still unclear, because we did not use appropriate methods to evaluate stability of the occlusion. That is one of the limitations of our study. Furthermore, more complex statistical analysis would be beneficial for a better illustration of the relationship between orofacial area and posture, as a matter of fact, spinal curves. It is not possible to evaluate the segmental stability (of the orofacial area) using only one parameter.

As Janda (1999) states, nothing is definitive, no conclusion is a dogma and there is never enough criticism.

Although we have shown some connections, the relationship between asymmetries in orofacial area and spinal curves is not clear, because of huge number of factors affecting both areas. However, occlusion and temporomandibular joints are important segments as well as pelvic floor, diaphragm or the abdominal wall for maintaining an upright body position and therefore we suggest not to omit this area when assessing patients posture, because we can find the primary disorder there. It is not necessary to do a complete examination of the dentition or MRI of the TMJs, but we suggest to evaluate stability and mobility of these two segments: of the occlusion and the TMJs. Indicators of instability are hypertonic muscles, TrPs, sound phenomena in TMJs, limited ROM in TMJs and the most important sign; pain. To find out, if the primary disorder is in the masticatory system, Okeson (2008) recommends to do the test of mouth opening: if the primary disorder is in the masticatory system, aggravation of symptoms will occur, if the primary disorder is elsewhere, no changes in symptoms will occur. Wainner et al. (2007) suggests to always screen segment above and below the area of primary complaint of the patient within first two visits.

The human body has a huge capability of compensatory mechanisms. Vařeka et Dvořák (2001) present consequences associated with impaired functions of the pelvic floor. Insufficient function of the pelvic floor does not allow optimal stabilization and straightening of the axial system. It is thus impossible to set an optimal posture and perform an optimal movement. The CNS uses another, less optimal, postural and motor programmes to reach the demanded goal. Initially, the impaired function of the pelvic floor does not necessarily have to be apparent thanks to the compensational and substitutional mechanisms, however, sooner or later these mechanisms will give up and the feeling of pain will inevitably arrive. The pain is felt in a different location than the primary disorder is in, and for successful treatment it is necessary to treat not only the painful location, but also the primary disorder (in this example the pelvic floor). Lack of occlusal stability might also induce compensatory and substitutional mechanisms, which are not optimal for postural function.

Cuccia et Caradonna (2009) point out a role of trigeminal afferents in maintaining postural control. They suggest that tension in the stomatognathic system can contribute to impaired neural control of posture. Numerous anatomical connections between the stomatognathic system's proprioceptive inputs and nervous structures are implicated in posture (cerebellum, vestibular and oculomotor nuclei, superior colliculus). If the proprioceptive information of the stomatognathic system is inaccurate, then head control and body position may be affected. Evidence continues to accumulate that untreated diseases of stomatognathic system, in particular temporomandibular disorders and malocclusion, carry a risk for development of postural disorders. Recent studies emphasize the potential role of the dental occlusion and of the trigeminal afferents in maintaining postural control.

5 CONCLUSION

We did not reveal any significant relationship between occlusion and any of the spinal parameters. However, we did find a relationship between jaw movement and scoliosis, vertebral rotation and amplitude of lateral deviations. When pathologies of the TMJ are present, the jaw pathway is altered and as the TMJ is one of the most loaded joints in the human body, these alterations can possibly influence the whole posture.

In today's physiotherapy we tend to look at the patient as a complex system and we are trying hard to find the real cause of patient's symptoms. When dealing with postural disorders, assessment of all body segments should be done and the orofacial area should not be omitted, because right there could be the primary cause of persisting musculoskeletal disorders.

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LIST OF PICTURES, TABLES AND FIGURES

APPENDIX

Informovaný souhlas účastníka studie: „Vliv ortognátní operace na páteř a posturu"

INFORMACE O PROJEKTU

Studie se zabývá vztahem mezi poruchami vzájemného postavení čelistí a páteře. Pacienti, u kterých je již indikována ortognátní operace stomatochirurgem, budou navíc vyšetřeni fyzioterapeutem (studentem fyzioterapie) pro možné odchylky v postavení páteře v systému 3D Moiré. Systém 3D Moiré je založen na principu optické interference vlnových délek viditelného spektra. Toto vyšetření podstoupí pacient před a po ortognátní operaci. Kontrolní skupinu budou tvořit pacienti se symetrickým postavením čelistí, kteří podstopí neradiologické vyšetření odborníkem ve stomatologii. Ve studii budou zaznamenány některé demografické údaje (věk, pohlaví). Součástí studie je dotazník, který slouží k doplnění informací o pacientovi.

Vyšetření 3D Moiré: Moiré topografie využívá fyzikálních vlastností viditelného světla, díky kterému jeho projekcí přes speciální mřížku (rastr) na povrch těla vytváří soustavu vrstevnic. Vyfotografováním a 3D zpracováním těchto vrstevnic je možné sledovat asymetrii páteře i celkové držení těla.

Ortognátní operace: Chirurgická úprava špatného postavení čelisti.

RIZIKA SPOJENÁ S TOUTO STUDIÍ

Tato studie neskýtá žádná rizika. Vyšetření 3D Moiré je neinvazivní, radiologicky nezatěžující a budou jej provádět kompetentní vyšetřující.

DŮVĚRNOST

Výzkumný tým se zavazuje, že bude s osobními daty - stejně tak jako s výsledky studie - nakládat s nejvyšší důvěrností a anonymitou, v souladu se zákonem č.101/2000 Sb., o ochraně osobních údajů.

Osobními daty se rozumí informace získané ze zdravotnické dokumentace, tedy: jméno, věk, pohlaví, zdravotní stav atd.

Osobní informace mohou vidět pouze autoři studie, kteří budou vykonávat statistické analýzy.

Anonymní a statisticky zpracované výsledky budou publikovány v bakalářské práci a odborném článku.

PŘÍNOS PRO ÚČASTNÍKY

Obdržíte vyhodnocení osobních výsledků z vyšetření páteře, tedy informace o křivkách páteře, rotace jednotlivých obratlů, posouzení symetrie zádového svalstva a postavení pánve. V případě zájmu také můžete dostat závěrečnou zprávu o výsledcích této studie. Účastí na studii přispějete k posouzení vlivu ortognátní operace na páteř a posturu, a také pomůžete poodhalit vztah mezi skusem čelistí a páteří.

Já, níže uvedený, dávám souhlas k účasti ve studii s názvem: **Vliv ortognátní operace na páteř a posturu**

Jméno: ....

Rodné číslo: ....

Identifikační kód..

1. Zcela dobrovolně souhlasím s účastí v této studii.

2. Byl(a) jsem plně informován(a) o účelu této studie, o vyšetřeních s ní souvisejících a o tom, co se ode mne očekává. Měl(a) jsem možnost položit jakýkoliv dotaz, týkající se použité metody i účelu této studie a potvrzuji, že všechny mé dotazy byly zodpovězeny.

3. Souhlasím, že budu plně spolupracovat s autory studie a jsem si vědom/a, že účast na studii je dobrovolná a mohu kdykoliv svou účast v této studii ukončit.

4. Chápu, že informace v mé zdravotnické dokumentaci jsou významné pro vyhodnocení výsledků studie. Souhlasím s využitím těchto informací s vědomím, že bude zachována důvěrnost těchto informací. (Potřebný je především přístup ke zdravotnické dokumentaci na Oddělení maxilofaciální chirurgie, kde autoři získají informace o postavení čelistí a chrupu pacienta a pacient tedy nemusí podstupovat další vyšetření jen pro účely studie. Za přínosné pro studii se považuje i nahlédnutí do anamnézy, kde mohou být informace například o jednostranném zatížení pacienta ve sportu, které může ovlivnit křivky páteře a celkovou posturu. Přístup bude umožněn pouze po dobu trvání studie.)

Autor studie: Michaela Hajduková; misa.hajdukova@gmail.com; +420 721 353 351

Vedoucí práce: MUDr. Otakar Raška, PhD.; raskaota@gmail.com

Podpis pacienta: „Souhlasím"

Datum:

Etická komise
Všeobecné fakultní nemocnice v Praze
ETHICS COMMITTEE
of the General University Hospital, Prague

Na Bojišti 1
128 08 Praha 2
tel.: 224964131
e-mail: eticka.komise@vfn.cz

Vážená slečna
Michaela Hajduková
Sokolovská 224/1297
190 00 Praha 9 Libeň

19.4.2018
č.j.: **217/18 S-IV**

Etická komise VFN projednala na svém zasedání 15.2.2018 a 19.4.2018 Vámi předložený individuální výzkumný projekt č.j. **217/18 S-IV – bakalářskou práci**

Název studie/*Title of CT*: Vliv ortognální operace na postavení páteř a posturu
Žadatel/*Applicant*: Michaela Hajduková, odd. maxilofaciální chirurgie VFN a 1 a 3.LF UK v Praze, U Nemocnice 1, 128 02, Praha 2 a Centrum pohybové medicíny Pavla Koláře, Pyšelská 4, 149 00 Praha 4
Lhůta pro podání písemné zprávy o průběhu KH od jeho zahájení/ *Time schedule for submission of the written Annual Report:* ☒ 1x ročně/*Once a year* ☐ Jiná lhůta/*Other*
Úhrada nákladů spojených s posouzením žádosti a vydáním stanoviska /*Reimbursement of costs related to assessment of the EC:* ☐ Ano/*Yes* ☒ Ne, důvod/*No, reasons*: Nesponzorovaný projekt

Datum doručení žádosti / *Date of submission of the Application Form:* 6.2.2018
Datum jednání EK+čas/*Date and time of Ethics Committee's session:*

1) **15.2.2018**(15,30 – 18,00 hod) – pozastaveno, oznámeno e-mailem, seznam čelenů bude dodán s konečným stanoviskem.
   - Opravené dokumenty dodány 14.2.2018 a 9.4.2018 pod čj. 291/18 D a 617/18 IS, D
2) **19.4.2018** (15,30 – 18,00 hod) – **souhlas**

Seznam míst hodnocení s označením míst, ke kterým se EK vyjádřila jako místní EK a kde vykonává dohled

Místo hodnocení / Jméno zkoušejícího ***Trial Site / Name of Investigator***	***Místní EK Local EC***	***Adresa místní EK Address***
Michaela Hajduková, odd. maxilofaciální chirurgie VFN a 1 a 3.LF UK v Praze, U Nemocnice 1, 128 02, Praha 2 a Centrum pohybové medicíny Pavla Koláře, Pyšelská 4, 149 00 Praha 4	☒	EK při VFN, Na Bojišti 1, 128 08 Praha 2

Seznam hodnocených dokumentů / *List of all submitted documents:*

Název dokumentu, verze, datum *Document title, version, date*	Schváleno /*Approved*		Na vědomí / *Taken into account*	
	ANO *Yes*	NE *No*	ANO *Yes*	NE *No*
Průvodní dopis, nedatován	☐	☐	☒	☐
Žádost o dotazníkovou akci, se souhlasem přednosty kliniky, 5.2.2018	☐	☐	☒	☐
Zkrácený formulář EK VFN k neintervenční dotazníkové studii u pacientů, 5.2.2018	☐	☐	☒	☐
IS účastníka studie	☐	☒	☐	☐
Čestné prohlášení o provádění výzkumu, 5.2.2018	☐	☐	☒	☐
Životopis zkoušející: Michaela Hajduková	☐	☐	☒	☐
Vyjádření vedoucí fyzioterapeutky Centra pohybové medicíny, nedatováno	☐	☐	☐	☒
291/18 D a 617/18 IS, D				
Popis bakalářské práce, nedatováno	☐	☐	☒	☐
Anotace studie v anglickém jazyce	☐	☐	☒	☐
Zkrácený formulář EK VFN k neintervenční dotazníkové studii u pacientů, 5.2.2018	☐	☐	☒	☐
Informace o projektu a IS účastníka studie	☒	☐	☐	☐
Vyjádření vedoucí fyzioterapeutky Centra pohybové medicíny, nedatováno	☐	☐	☒	☐

Stanovisko etické komise:
EK vydává / *EC issues*

☒ Souhlasné stanovisko/*Favourable opinion*
☐ Nesouhlasné stanovisko/*Unfavourable opinion*

EK VFN vydává **souhlasné** stanovisko k provedení individuálního výzkumu: bakalářské práce: Vliv ortognální operace na postavení páteř a posturu na odd. maxilofaciální chirurgie VFN a 1.LF UK v Praze a v Centrum pohybové medicíny Pavla Koláře

Etická komise
Všeobecná fakultní nemocnice
v Praze
Na Bojišti 1
128 08 Praha 2

Podpis předsedy EK / *Signature of Chairperson*

MUDr. Josef ŠEDIVÝ, CSc.

Seznam členů etické komise/ *List of the Ethics Committee Members:*

	Muž/ Žena *Male/ Female*	Odbornost *Specialist*	Zaměstnanec zřizovatele EK* Ano Yes	Ne No	Funkce v EK *Role in EC*	Přítomen *Attendance* Ano *Yes*	Ne *No*	Hlasoval *Voted* Ano *Yes*	Ne *No*
MUDr.Josef Šedivý, CSc.	M/M	Clinical Pharmacologist	☒	☐	Předseda/ Chairperson	☒	☐	☒	☐
MUDr.Magda Šišková, CSc.	Ž/F	Haematologist	☒	☐	Místopředseda/Vice-chairperson	☒	☐	☒	☐
JUDr.Milada Džupinková, MBA	Ž/F	Lawyer	☒	☐	Člen/Member	☒	☐	☒	☐
Jana Farkačová	Ž/F	Lab.Technician	☒	☐	Člen/Member	☐	☒	☐	☒
Doc.MUDr.Pavel Freitag, CSc.	M/M	Gynaecologist	☒	☐	Člen/Member	☐	☒	☐	☒
Ing.Antonín Grošpic, CSc.	M/M	Engineer	☐	☒	Člen/Member	☒	☐	☒	☐
Prof.MUDr.Eva Kubala Havrdová, CSc.	Ž/F	Neurologist	☒	☐	Člen/Member	☐	☒	☐	☒
MUDr.Hana Honová	M/M	Oncologist	☒	☐	Člen/Member	☒	☐	☒	☐
MUDr.Anna Jedličková	Ž/F	Microbiologist	☐	☒	Člen/Member	☐	☒	☐	☒
MUDr.Jiří Kolář	M/M	Cardiologist	☒	☐	Člen/Member	☐	☒	☐	☒
MUDr.Ladislav Korábek, CSc., MBA	M/M	Dental surgeon	☒	☐	Člen/Member	☒	☐	☒	☐
Prof.MUDr.František Perlík, DrSc.	M/M	Pharmacologist	☒	☐	Člen/Member	☒	☐	☒	☐
Prof.MUDr.Jan Roth, CSc.	M/M	Neurologist	☒	☐	Člen/Member	☒	☐	☒	☐
Mgr.Libuše Roytová Mgr.ThLic.of Theologie	Ž/F	Member of clergy	☐	☒	Člen/Member	☒	☐	☒	☐
MUDr.Kateřina Rusinová, MgA.,Ph.D.	Ž/F	Anesthesiologist -Intensive Med.	☒	☐	Člen/Member	☐	☒	☐	☒
JUDr.Šárka Špeciánová	Ž/F	Lawyer	☐	☒	Člen/Member	☒	☐	☒	☐
MUDr.Marcela Trojánková	Ž/F	Privat Nefrologist	☐	☒	Člen/Member	☒	☐	☒	☐
Prof.MUDr.Jiří Zeman, DrSc.	M/M	Paediatrist – AdolescentMed	☒	☐	Člen/Member	☒	☐	☒	☐

pozn: *Zaměstnanec zřizovatele EK/ *Employee of EC appointing authority)*

Etická komise prohlašuje, že byla ustavena a pracuje v souladu se správnou klinickou praxí (GCP) a platnými právními předpisy. Poslední sloupec udává, zda členové EK byli přítomni hlasování, ale nikoli jak hlasovali ve věci./*The Ethics Committee hereby declares that it was established and operates in accordance with its Rules of Procedure in compliance with GCP and valid legal regulations. EC members personally presented the voting procedure (and NOT their individual voting result to or against the cause) are indicated in the last column :*

☒Ano/*Yes* ☐Ne/*No* Komentář/*Comments:*

Datum/*Date*: 15.2.2018

Podpis předsedy EK nebo zástupce
Signature of Chairperson or Vice-Chairperson
MUDr.Josef Šedivý, CSc.

Etická komise
Všeobecná fakultní nemocnice
v Praze
Na Bojišti 1
128 08 Praha 2