Is There A Difference In The Range Of Cervical Motion Between People With An Overbite And People With A Normal Occlusion?

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by

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Abstract

Peter G. Bracken

Is There A Difference In The Range Of Cervical Motion Between People With An Overbite And People With A Normal Occlusion?

The purpose of this study was to evaluate whether there is a co-relationship between malocclusion and the motion of the cervical spine. A two by two comparative research study was developed to compare subjects with overbites to subjects with normal occlusion. A total of forty-two participants were tested in two groups of twenty-one. There was a second part of the study where an intervention was used. The intervention involved repeating the measurements after the subjects had bitten on dental rolls. Each person was measured for maximum Range of Motion (ROM) of the cervical spine sitting using a ZEBRIS three dimensional ultra sound device. Parameters measured were extension, flexion, rotation and lateral flexion.

The results of the first measurements showed a clear difference between the test and control groups. The control group with a normal occlusion show a greater range of cervical motion in all measured parameters compared to the control group. The effect of the intervention had no significant influence on the range of motion (ROM) of both groups. A balancing out effect between left and right for rotation and lateral flexion was identified but only in the control group.

Key words: Posture, Scoliosis, Overbite, Occlusion, Mandible, Malocclusion, Dentation, Cervical Spine, Cervical Range of Motion, Spine, Temporomandibular Joint (TMJ), Angle Classification, TMJ Dysfunction, Bruxism, Clenching

Abstract Deutsch

Peter G. Bracken

Gibt es einen Zusammenhang zwischen der Beweglichkeit der Halswirbel-säule bei Personen mit Überbiss und Personen mit normaler Okklusion?

Das Ziel dieser Studie war es herauszufinden, ob ein Zusammenhang zwischen einer Zahnfehlstellung und der Beweglichkeit der Halswirbelsäule besteht. Deshalb wurde eine two by two Grundforschung Studie entwickelt um Testpersonen mit einem Überbiss und eine Kontrollgruppe mit normaler Zahnstellung vergleichen zu können. Die aus 42 Teilnehmern bestehende Gesamtgruppe wurde in zwei Gruppen zu je 21 aufgeteilt.

Im zweiten Teil der Studie wurde eine Intervention ausgeübt. Diese bestand darin, die Teilnehmer auf Dental-Watte-Rollen beißen zu lassen und anschließend die Messungen erneut durchzuführen. Bei jedem Probanden wurde in sitzender Position die maximale Beweglichkeit der Halswirbelsäule mit einem ZEBRIS 3-Dimensionalen Ultraschall Gerät gemessen. Die gemessenen Parameter waren Extension, Flexion, Rotation und Laterale Flexion.

Das Ergebnis der ersten Messung zeigt einen deutlichen Unterschied zwischen der Test- und der Kontrollgruppe. Die Gruppe mit normaler Okklusion (Kontrollgruppe) zeigt im Vergleich zu der Testgruppe eine weit größere Beweglichkeit der Halswirbelsäule in allen gemessenen Parametern. Die Intervention hatte bei beiden Gruppen keinen signifikanten Einfluss auf den Grad der Beweglichkeit. Allerdings zeigte sich bei der Kontrollgruppe ein ausgleichender Effekt zwischen der Rechts- und Linksrotation und der Lateralflexion durch die Intervention.

Schlüsselwörter: Haltung, Skoliose, Überbiss, Okklusion, Mandibular, Malokklusion, Zahnentwicklung, Halswirbelsäule, Beweglichkeit der HWS, Wirbelsäule, Temporo-mandibular Gelenk (TMG), Angle Klassifikation, Cranio-Mandibular Dysfunktion (CMD), Bruxismus

Contents

1 Introduction

The influence of occlusion on the spine and posture is a prominent topic in most manual therapies and naturally in the field of Orthodontics. Osteopaths, working in the field of pediatrics, are often confronted with the topic of occlusion either as a primary problem and concern of parents, or as a finding within a broader examination. Posture is not the only consideration when evaluating malocclusion but probably the most common.

Just as feet are considered the foundation of the human skeleton, our occlusion is considered to be a fundamental factor influencing the suspension of the head and upper body. Parents frequently ask Osteopaths about what role occlusion plays in childhood development and the ramifications of Orthodontic treatment. They have concerns about the general well-being and development of their growing children. Ear, Nose and Throat issues often appear before or together with occlusion problems showing just how interrelated many health issues are.

Extensive research has taken place by Orthodontists regarding the influence of malocclusion on teeth, the jaw, chewing and biting but also speech, breathing, digestion and posture. In Osteopathy, posture would appear to be the most obvious subject of concern but, health, the primary focus of Osteopathic treatment, involves all body systems functioning well and underlines the importance or the co-relationships of occlusion with all physiological systems of the body. All the same, the purpose of this study was to examine the co-relationship of occlusion and the spine as it is an important issue in the osteopathic practice today.

After reviewing the literature available on occlusion and posture, a decision was made to investigate the range of measurement possibilities used so far for either posture (static) or movement/mobility (active). Upon receiving a generous offer from the company ZEBRIS to use their 3D motion analyzer, we decided to examine just one form of malocclusion, an overbite, and look at the inter-relationship with a precise area of the spine, the neck. Originally a cross-bite in the form of a lateral deviation of the mandible to the left or right was considered but sourcing appropriate subjects proved very difficult. Cross-bites and lateral deviations of the mandible are often associated with skull asymmetries resulting from birth or fetal development disturbances. These deviations are usually corrected quickly from Orthodontists and, after considering this, we decided to use the malocclusion group overbite instead. Overbites are and were much easier to find as even after orthodontic treatment, they are still recognizable. This meant that the deviation was no longer lateral but rather anterior-posterior. The idea developed into the first part of a comparative research study in which we decided to compare overbites to people with normal occlusion.

It is important to consider what is normal occlusion, what is an overbite, what is the normal movement of the neck and what is a normal range of motion. These aspects are looked at later.

A second part of the study was then considered with the idea of introducing an intervention. After comparing the groups to each other, it was decided to see how they react to a specific task. In many osteopathic education courses involving the jaw, a diagnostic test is frequently presented which involves patients biting on paper or something similar in order to change the position of the jaw and the tension of the muscular around it. The idea is that a change in position of the Temporomandibular Joint (TMJ) and the tension around it will effect tension and function of other biomechanically and neurologically interrelated areas of the body. This is commonly referred to as the Meersseman Test which is explained later. In our study both groups of subjects bit on common dental rolls as a form of intervention and the effect was then documented.

2 Background Literature

The literature research began with the key words 'posture, overbite, malocclusion, cervical spine, cervical motion and Meersseman Test' using Google Scholar. These sources listed books, articles and other publications mentioning these words. The sources included PubMed, Cochrine Library, and numerous medical journals such as Spine and Physical Therapy. References to the Meersseman Test in Osteopathic Education institutions in Germany and Austria were also made. This led to new groups of Key Words and Terms that appeared with the Meersseman Test including 'CMD, TMJ, TMJ dysfunction, and scoliosis'. Searches were made directly to Osteopathic Journals and Research Centers, Orthodontic Journals, Physiotherapy Journals and Kinesiology Journals. The searches were in most cases limited to the last ten years and to the main theme of occlusion and posture. In many cases, older literature was still very relevant. Later, related terms such as 'Angle classes, bruxism, whiplash, clenching, and plagiocephalus', were researched in relation to the nature of specific disturbances and definitions. A separate search was conducted into the use and reputation of the measurement tool. This involved researching the validity of the Zebris Cervical Mobility Analyzer.

The effects of Malocclusion on posture and spinal movement have been examined in numerous clinical studies. Perillo, Signoriello, Ferro, Baccetti, Masucci, Apicella, Sorrentino, Gallo (2001), looked at different types of occlusion and posture variations in 703 12-year-olds. They failed to find any correlations between Angle Class III and backward posture or Angle Class II (overbite) and forward posture. What they did find were variations that appeared to have a regional connection. Shimazaki, Motoyoshi, Hosoi and Namura (2003), in their study showed that lateral displacement of the mandible effects the muscular balance of the jaw and cervical spine, resulting in changes to head and neck symmetry. Korbmacher, Koch, Egger-Stroeder, Kahl-Nieke (2007), used palpation and radiographs to assess whether unilateral cross-bites were associated with asymmetry of the upper cervical spine. Here the results suggest that they do. Fifty-five children aged 3-10 years were compared to fifty-five age matched children with symmetric occlusion. Hanke et al. (2007), in a systematic review found 266 articles with reference to dental findings and orthopedic conditions and 216 relating to posture of the head, but most failed to provide solid evidence in the form of quality research. Klemm (2008), in an osteopathic study looked at short-term changes to the position of the jaw and examined the influence of a unilateral change of occlusion on upper cervical range of motion with subjects who had normal occlusion. Although he could not detect any significant short-term changes to the range of motion, the intention in this study was to compare the Range of Movement (ROM) in subjects with long-term existing malocclusion to those with normal occlusion using the same method of measurement. Armat (2008), in his assessment of the literature on regarding occlusion, orthodontics and posture showed that the evidence is poor and one reason is that it appears that there are numerous contributing factors. Tardieu, Dumitrescu, Giraudeau, Blanc, Cheynet, and Borel (2009), found contradictory results in the literature regarding occlusion and postural control. They hypothesized that one reason is the difference between static and dynamic test tasks. Sacucci, Tettamanti, Mummolo, Polimeni, Festa, Saliniand Tecco (2011), in their literature review on scoliosis and occlusion concluded that that there is plausible evidence for a correlation. Here the emphasis is unilateral changes from jaw to spine. They examined unilateral Angle Class II malocclusion together with scoliosis. Hülse and Losert-Bruggner (2011) looked at the co-relationship of the jaw and upper cervical spine. They report that in cases of trauma to the upper cervical spine, e.g. whiplash, the Temporomandidular Joint (TMJ) was automatically affected and conclude that dysfunction in the TMJ will in the same sense, effect upper cervical function. This phenomena is looked at in more detail later. Schmitt (2010), I another osteopathic study, investigated the correlation of an Angle Class II occlusion and the existence of scoliosis. Within this occlusion classification, there are a number of variations including one-sided cross-bites and overbites. Schmitt's results pointed to a correlation for the one-sided Angle Class II occlusion and scoliosis.

3 Related Topics and Definitions

3.1 Angle Classification and Dentation

Edward Angle, an American Dentist born in 1855, is often referred to as the father of modern orthodontics, and was the first to classify malocclusion. He based his classifications on the relative position of the maxillary first molar. According to Angle, the mesiobuccal cusp of the upper first molar should align with the buccal groove of the mandibular first molar. Any variations from this resulted in malocclusion types. It is also possible to have different classes of malocclusion on left and right sides. The following definition of the three classes is from Wikipedia and is almost identical to the definition found in every orthodonitic text book and Angle's original script. (Source: Wikipedia)

Class I: Neutrocclusion Here the molar relationship of the occlusion is normal or as described for the maxillary first molar, but the other teeth have problems like spacing, crowding, over or under eruption, etc.

Class II: Distocclusion (retrognathism, overjet) In this situation, the upper molars are placed not in the mesiobuccal groove but anteriorly to it. Usually the mesiobuccal cusp rests in between the first mandibular molars and second premolars. There are two subtypes:

Class II **Division 1:** The molar relationships are like that of Class II and the anterior teeth are protruded.

Figure 1. Class II excessive overjet

Class II **Division 2:** The molar relationships are class II but the central are retroclined and the lateral teeth are seen overlapping the centrals.

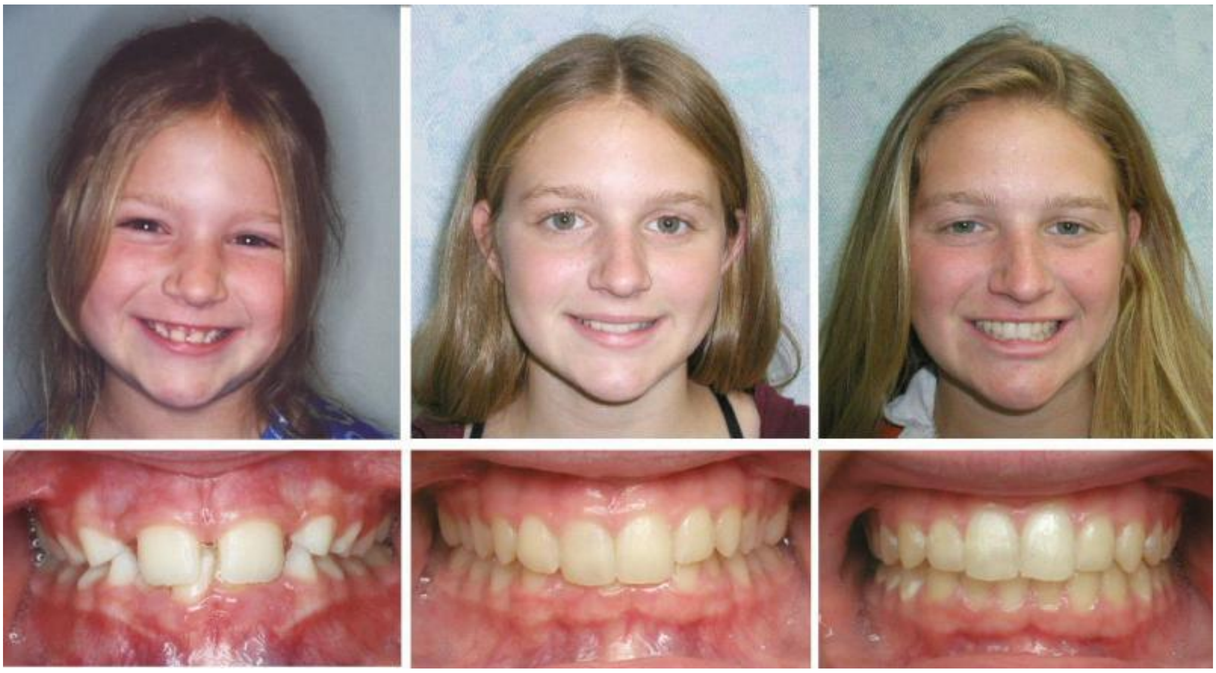


Figure 2. Class II deep overbite

Class III: Underbite: Mesiocclusion (prognathism, negative overjet) In this case the upper molars are placed not in the mesiobuccal groove but posteriorly to it. The mesiobuccal cusp of the maxillary first molar lies posteriorly to the mesiobuccal groove of the mandibular first molar. Usually seen as when the lower front teeth are more prominent than the upper front teeth. In this case the patient very often has a large mandible or a short maxillary bone.

Figure 3. Angle Classes, Source google pictures

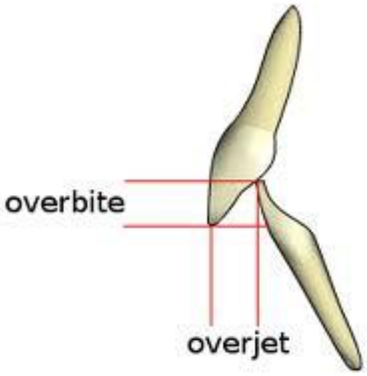


Figure 4. Overbite and Overjet

Figure 5. Overbite and Overjet

There is a difference between overbite and overjet but they often come together and fall into the Angle Class II Dentition. In this study a distinction between the two terms has not been made and all test subjects have a symmetrical Class II Dentition.

Malocclusion can be described as a functionally unsatisfactory relationship of the teeth according to Cobourne and DiBiase (2011) but is not a disease. The Angle Classification denotes three classes of Occlusion based on the position of the first permanent upper and lower molar but there are numerous sub-classes, as shown above, with variations left and right. What is interesting is that Huang and Richards (2011) conclude that even though ideal occlusion can be defined, it is not so common to find it. The etiology of malocclusion according to Cobourne et al. include evolutionary trends showing that it is increasingly becoming more common, genetic influences, environmental factors, soft tissue pressure, mouth breathing, muscular activity, sucking habits, trauma, periodontal disease, and early primary tooth loss. Some of these factors will be looked at in more detail later.

Development of Dentition

Two sets of teeth develop in a person's lifetime. At the age of approximately six months, the deciduous (primary) teeth begin to erupt starting with the incisors. By the age of two and a half years of age, all the 20 deciduous teeth will have emerged which include incisors, canines and molars. These will be replaced by the 32 permanent teeth in a predictable order. This takes place at about age 6 and continues through to about age 16. Wisdom teeth on the other hand can appear much later (17-25 years) when the jaw has reached its final size. For this reason, wisdom teeth have the potential to cause crowding and impaction.

There are naturally greater variations in tooth emergence than tooth formation. The normal sequence of permanent teeth eruption according to Rauber/Kopsch is:

Tooth	Eruption	Sequence	
1	6-9 years	2	
2	7-10	3	
3	9-14	5	
4	9-3	4	
5	11-14	6	
6	6-8	1	six year molar
7	10-14	7	twelve year molar
8	16-30	8	wisdom tooth

Table 1. Dentation Timetable for Permanent Teeth

3.2 Motion of the Cervical Spine

The mobility of the cervical spine can be broken down into the upper and the lower segments. The atlas-axis complex is responsible for 50% of our cervical rotation and the other 50 % is spread over the rest of the cervical segments. It is therefore possible to differentiate between these two components by rotating the head at different angles of the neck. Rotation can be measured together with maximum flexion, maximum extension and in the neutral position. For the purpose of this study, the neutral or combined rotation position was used.

Figure 5. Rotation Flexion Extension Lateral Flexion . source: spineproducts .com

Normal ranges of movement are difficult to define as gender and age play an important role. Youdas Garrett, Suman, Bogard, Hallman and Carey, (1992), measured the active cervical range of movement (AROM) in 337 healthy subjects ranging in age from 11 to 97 years. They found that females had a greater AROM in extension lateral flexion and rotation with the exception of flexion. They also found that for every decade in age, both males and females lose approximately 5 degrees of extension and 3 degrees in the other movements. Flexion for example, can be normal from 36° to 64°.

Lind, Sihlbom, Nordwall and Malchau, 1989, looked at the maximum range of extension and flexion using radiographs and found that the largest inter-segmental flexion-extension motion occurred between C4/C5 and C5/C6.

Figure 6. Neutral, Max. Extension and Max. Flexion Source: boneandspine.com

3.3 The Temporomandibular Joint

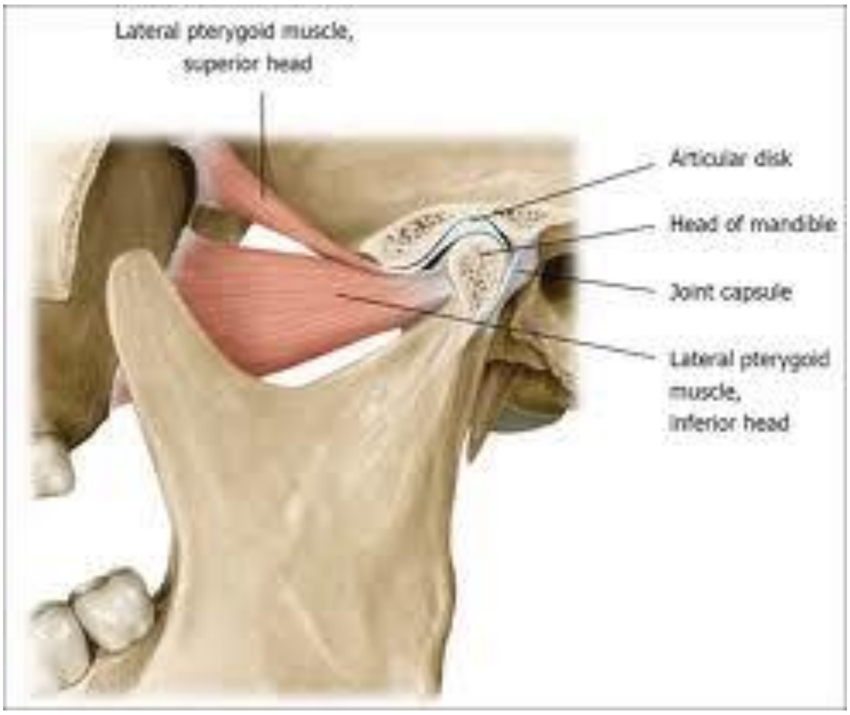


Figure 7. Anatomy of the Temporomandibular Joint, Source Netter images

The TMJ is a very complex joint due to the functions it must forfill. These include chewing, biting, tearing, grinding, swallowing, clenching and speaking. It can be considered a ginglymoid joint as it hinges, and an arthrodial joint as it must glide. The mandibular condyle fits into the mandibular fossa of the temporal bone. Separating the two bones is an articular disc which provides a third articular element. The disc is attached to the capsular ligament laterally, posteriorly and anteriorly. The cavity contains endothelial cells which forms a synovial lining and is therefore also considered a synovial joint. The TMJ has a relatively loose capsule and is secured by the sphenomandibular ligament which arises from the sphenoid bone and runs down to the lingula of the mandible, the stylomandibular ligament which arises from the stylois process and runs down and forward limiting protrusion movements, and the lateral ligament which runs down and posteriorly close to the joint .

There are four true muscles of mastication. The **masseter, temporalis**, **medial pteriogoid** and **lateral pterigoid** muscles. The masseter and temporalis are powerful elevators of the mandible in synergy with the medial pteriogoid muscle. The primary function of the medial and lateral pteriogoid muscles is to allow grinding movements. The lateral pteriogoid muscle also protracts the mandible and tensions the articular disc. While the inferior lateral pteriogoid is protracting the condyle forward, the superior lateral pteriogoid is inactive and only activates with a powerful bite.

Mastication involves biting and chewing but the mouth and jaw also need to be opened. This can take place passively or with the help of the suprahyoid muscles. These include the two bellied **digastic** muscle reaching from the mandible to the hyoid bone. This muscle can open the mouth or raise the hyoid. The **mylohyoid** muscle forms the floor of the mouth and can raise it to assist in swallowing. The other two suprahyoid muscles are the g**eniohyoid** which raise the hyoid and the **stylohyoid** which elevates and retracts the tongue.

The myotatic reflex, used in the neurological examination, is activated by a sudden downward force to the chin. This prevents further stretching and the mandible is retracted. This happens without influence from the cortex and is important for the resting position of the jaw. The nociceptive reflex is a polisynaptic reflex and prevents overloading of the jaw and damage to the teeth. The greatest amount of force is in the region of the first molar but we rarely use maximum force. According to Okeson (2004), normal chewing and grinding involves about 36% of the potential muscular force.

The trigeminal nerve is a mixed nerve with motor functions originating from the nuclei within the pons and sensory functions terminating in nuclei within the midbrain, pons, and medulla oblongata. Three nerves arise from the trigminal (gasserian) ganglion and include the **ophthalmic** nerve, the **maxillary** nerve and the **mandibular** nerve. The latter innervates the muscles of mastication including some muscles of the mouth floor. The sensory functions are far greater than the motor functions and include sensations of touch, temperature and pain from the face.

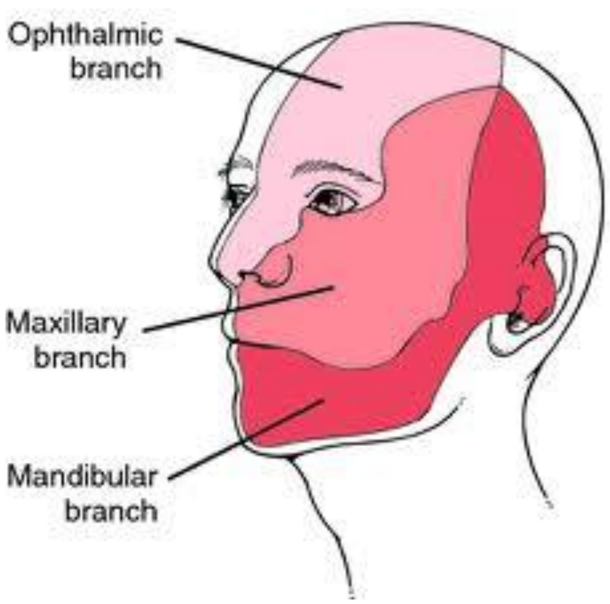


Figure 8. The branches of the trigeminal nerve and their innervation areas Source google pictures

The sensory **ophthalmic** nerve also innervates the upper eyelid, surface of the eyeball, lacrimal gland, side of the nose, and upper mucosa of the nasal cavity. The **maxillary** nerve sensory innervation includes the inferior mucosa of the nasal cavity, palate and parts of the pharynx, teeth and gums of the upper jaw,upper lip, and skin of the cheek. The **mandibular** nerve transmits information from the teeth and gums of the lower jaw, anterior two thirds of the tongue, nucosa of the mouth, auricle of the ear and lower part of the face. The anterior belly of the diagastric muscle is innervated by the **mandibular** nerve and the posterior belly is innervate by the **facial** nerve.

3.4 Temporomandibular Dysfunction

The very first action of a baby after delivery is to breathe and secondly to suckle the breast of the mother. The activation of the jaw and face muscular plus positioning the mandible and head are one of the very first activities of life. Later as a young infant, chewing and speaking become important activities of development. A functional disturbance to the TMJ has the potential to effect the ability to speak, drink, chew, swallow, close the mouth, and breathe normally through the nose. One of the most common disturbances to jaw function is a posterior positioning of the mandible. The mandible must be able to glide forward and to both sides. It has no bony attachments. Considering that twenty minutes of teeth contact daily is considered normal, the mandible should be neutrally suspended most of the time. Two very common symptoms reported in the practice relating to the jaw and teeth are clenching and grinding (Bruxism). Manfredini, Winocur, Guarda-Nardini and Lobbezoo (2013) reported that Bruxism is a common problem with a prevalence range from 8–31 % in the general population, children included. Lobbezoo and Lavigne (1997) looked at the corelationship of Bruxism and temporomandibular disorders (TMD) and concluded that evidence is not clear. Some hypothesise that they coexist, others that it is a form of TMD but there should be a distinction between daytime and night-time grinding or sleep bruxism (SB). Pressing the teeth together with excessive tension of the jaw muscular is referred to as parafunctional clenching. It is related to bruxism, and can be observed in children and adults alike. The reasons for this appear multi factual but clenching is common together with a retro-positioned Mandible and other TMJ disorders. Glaros and Burton (2003) concluded that parafunctional clenching is an important cause of pain and can lead to TMJ dysfunction in otherwise pain-free individuals. Additionally, there is a co-relationship with increased pain and activity of the masseter muscle. Bader and Lavigne (2000), consider sleep bruxism to be a stereotyped movement disorder, and is characterized by grinding or clenching. They report that SB is more frequent with younger people and commonly appears in childhood. The research their reviewed did not identify any clear aetio-pathophysiology, but associations were made with tooth interference, psychosocial and environmental factors, brain transmitters and basal ganglia dysfunction. Attempts have been made to specify vulnerable personality types such as those with greater anxiety and exposure to stress. Although this is not clear, many bruxers have accompanying somatic problems. Even though there is no specific treatment for sleep bruxism, it is a condition commonly reported in clinical osteopathic practice. Dentists will normally provide patients suffering from SB with a mouth guard to prevent tooth damage.

TMJ Disorders generally fall into three broad categories: structural incapacity of the articular surfaces, disturbances of the condyle-disc complex and inflammatory joint disorders. Disruption of the normal condyle-disc movement is often associated with 'clicks', ' pops' and crebitation. The disc is medially and laterally bound to the condyle by strong connective ligaments. Okeson describes how the disc can only rotate on the condyle and the disc can only translate on the articular fossa due to the ligament structures. This movement of the disc is limited by the colateral ligaments, the retro discal lamina and the anterior capsular ligament. When the mouth opens, the disc rotates posteriorly and the discal lamina becomes stretched in order to translate out of the fossa. The elevating muscles provide pressure to centralise the condyle on the thinner intermediate zone of the articular disc. When a person bites, the intra-articular pressure of the ipsilateral joint decreases and superior lateral pterygoid muscle pulls the disc complex forward. This allows the disc to stay in contact with the articular surfaces. The retro-lamina is the only structure which can retract to disc posteriorly but this can only happen when the condyle is translated forward. The disc maintains its position due to its form and the interacticular pressure. If the morphology changes, the disc can slide on the surface of the condyle. This can happen when the disc changes its form and the ligaments become elongated. The superior pterygoid muscle can now pull the disc forward and medial. When a person opens their mouth and a 'pop' is heard, the disc finds its proper position. The dysfunction of the articulating structures will increase with increased muscle tension and, in particular, tension of the superior pterygoid muscle.

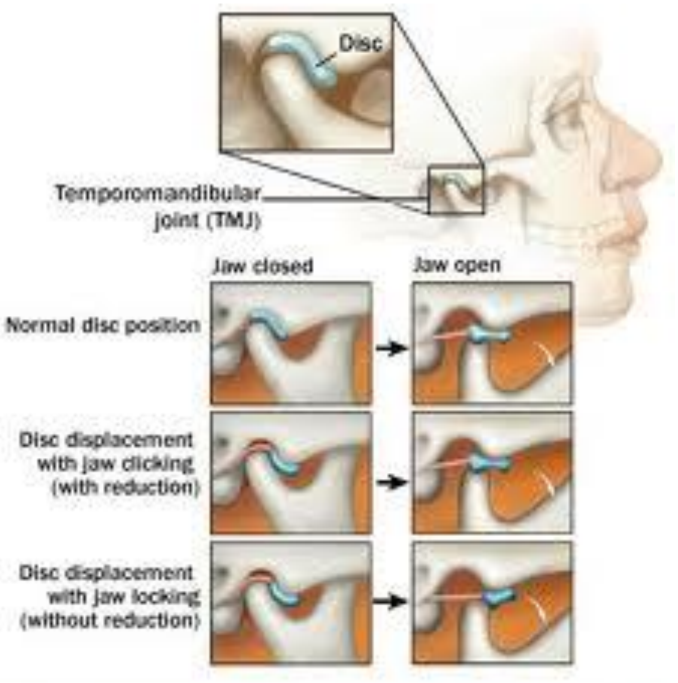


Figure 9. Articular Disc Displacement: Source: connecticutfamilychiropractic.com

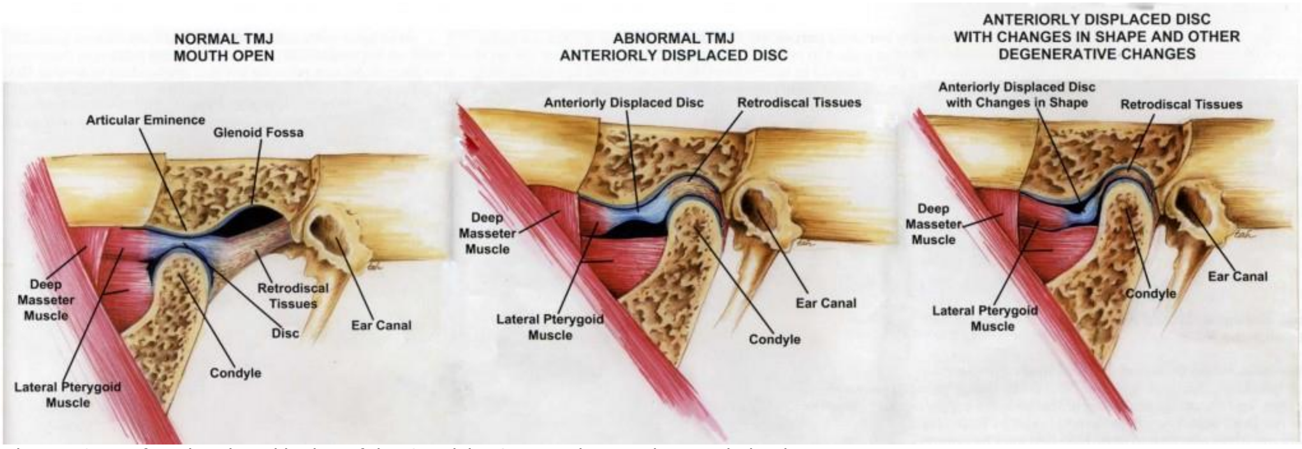


Figure 10. Dysfunctional positioning of the Condyle, Source: leawoodcosmeticdentistry.com

Changes in the morphology of the TMJ can appear early in childhood development as is the case with other acticular areas such as the hips and feet. These changes may not be initially obvious but as the demands on the jaw increase, so do the symptoms of irregularities. Condyle form and angle of the fossa, for example, can change unilaterally or bilaterally. The TMJ is not only susceptible to developmental conditions but also trauma. One of the most common issues faced by paediatric Osteopaths are toddlers falling on their face and chin during the early phases of upright locomotion. Often the first natal teeth are damaged and not uncommonly the temporomandibular joint complex is compressed. If the forces are high enough, condyle form and development can be negatively influenced. Adults are not immune to such trauma and often receive blows to the face and mandible.

3.5 The Interaction of the Cranial-Cervical and the Temporo-Mandibular Regions

In the clinical environment it is not unusual to see and treat patients suffering from the effects of so called whiplash accidents. This involves a rapid uncontrolled and unexpected movement of the head back and forth or side to side. The cervical spine experiences over stretching of the passive structures such as ligaments and joint capsules irritating joints and muscles. This results in muscular stiffness and pain. What is not so apparent is that whiplash patients commonly develop TMJ disorders following such incidences. It is not uncommon for patients suffering neck pain to report that they experience pain and muscle contraction in the face and jaw (Maitland 1991).

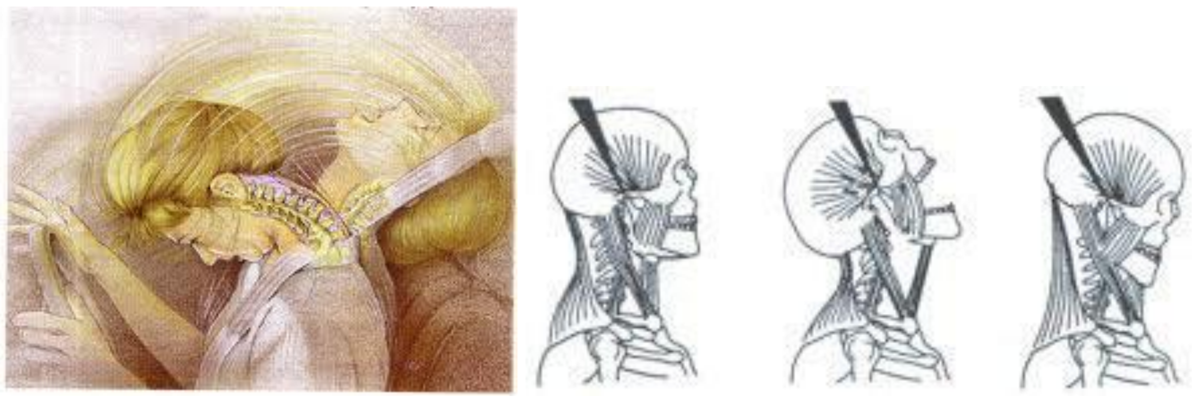


Figure 11. Whiplash and Reaction of the Mandible, Source: paindoctor.com

Hülse et al. (2009) investigated 187 patients with chronic complaints following cervical-vertebral whiplash trauma with regard to the existence of TMJ dysfunction. They found in all cases, using function and clinical tests, evidence of dysfunction. In another survey of 136 TMJ dysfunction Patients, 82% had a lowered occlusion level with crowding of the anterior mandible. These are two typical signs of a posterior positioned mandible such as an overbite, with compression of the bi-lamina zone of the TMJ complex.

3.6 Osteopathic Considerations

Osteopaths such as Magoun (1962), and Möckel, Mitha (2006), on the other hand identify fetal development and birth as a major factor for malocclusion and TMJ dysfunction. The skull is at birth very adaptable in order to successfully pass through the birth canal and in most cases recovers well to the compression forces of delivery. Osteopaths have long considered the intrauterine period as an important origin of compression problems which appear later after delivery. The fluid space available to the developing fetus is influenced by many factors. These include:

- existence of twins
- reduced amount of embryonic fluid
- a short umbilical cord
- an umbilical cord around the neck
- changes to the pelvis of the mother
- size of the embryo
- placenta variations

These conditions effect the ability of the child to move resulting in pressure being exerted on parts of the fetal body, for example, the skull, the feet and pelvis. Such compression points may possibly affect the speed and form of early infant development resulting in, for example, metatarsus varus, hip dysplasia and plagiocephalus. The latter is of great importance to the subject of occlusion particularly at early adulthood when orthodontic treatment is considered. In the first months the existence of plagiocephalus influences the resting position of the infant head which automatically influences the position and function of the cervical spine. Plagiocephalus can affect either the neural skull regions or the facial skull regions and possibly both. If these compressional forces change the position of the temporal bones, it can affect the position of the jaw; changes to the occipital bones can affect the position of the atlas. Such changes early in life have the potential to influence suckling, breathing, motor control of the head and digestion. Feet deviations at birth such as metatarsus varus and hip dysplasia are important issues when the infant begins to develop motor skills i.e. rolling, crawling, standing and walking. After the upright position has been reached the spine will take on its characteristic 'S' form. The conditions mentioned above play an important role in early childhood development and for the reason are also important issues in osteopathic treatment.

Figure 12. Plagiocephalus

Figure 13. Helmet Therapy, Source: cranioform Group

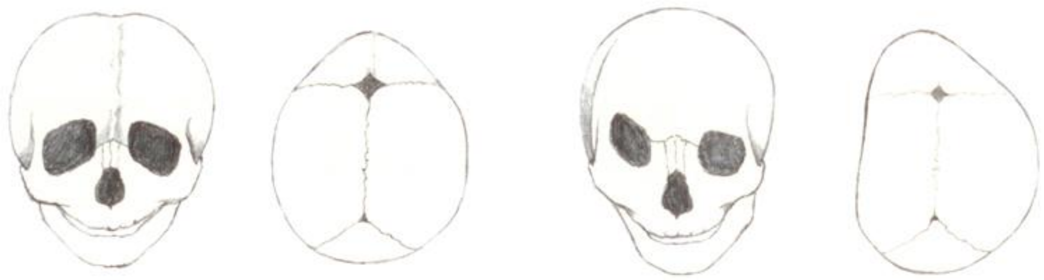


Figure 14: . Trigonocephalus (Triangle Skull), Plagiocephalus (One-sided fusion of a sutura) ,

Source: Universitätsklinikum Würzburg

Figure 15. Changes to Skull Symmetry effecting the position of the jaw

In adulthood, the asymmetrical changes to the face and skull have the potential to cause lateral deviations in the jaw. This is also the case with anterior-posterior deviations and can also be observed with overbites.

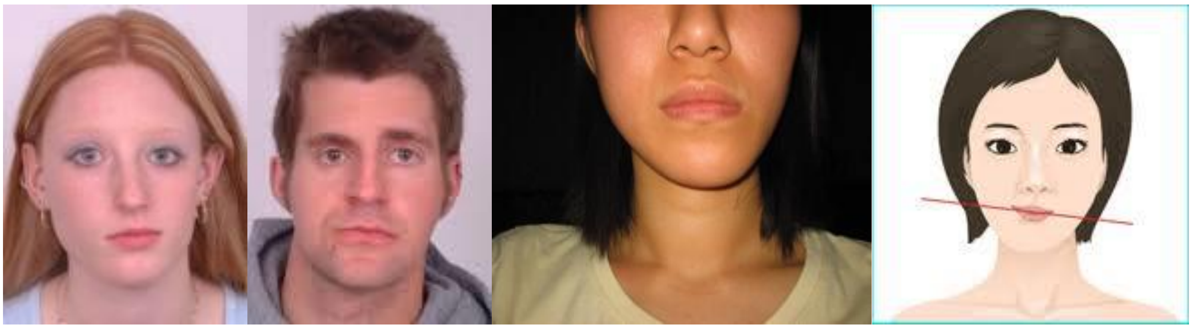


Figure 16. Asymmetrical Jaw Positions, Source: google pictures

P.H. Ridder (1993) in his analysis of such changes to the position of the jaw recorded the following common accompaning symptoms:

- Migränes
- Tinnitus, Hypertympany
- Vertigo
- Neck pain (later in detail)
- Shoulder arm syndrom
- Lumbago
- Torticollis
- Clicking of the jaw (later in detail)
- Burning eyes
- Problems opening the mouth

3.7 Occlusion and Posture

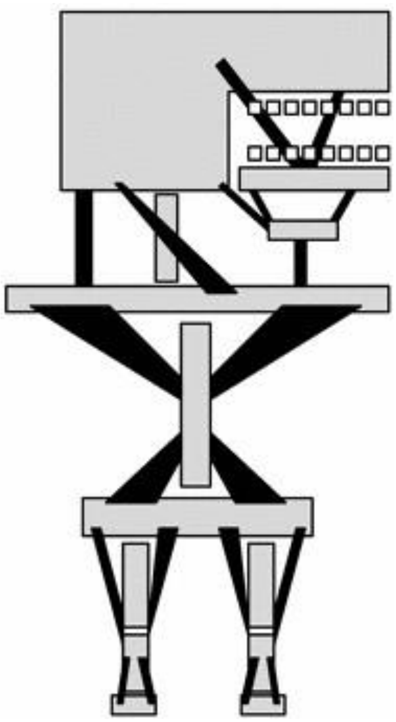
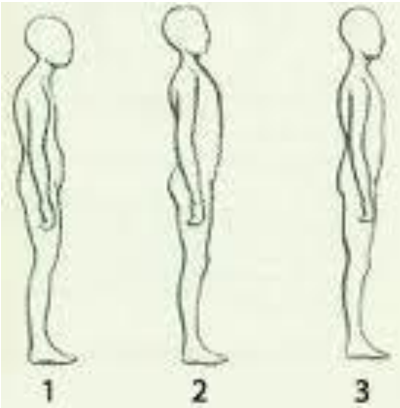


Figure 17. The functional anatomical corelation of the jaw to the rest of the body according to Dr. P.H. Ridder

Osteopaths such as Littlejohn described early on the co-relationship of the jaw and posture. He defined two gravity lines and a functional triangle from the mandible to the fourth thoracic vertebra and the base of the skull. Edward Hall described a ventral and a dorsal posture. The dorsal type of posture (1) is characterized by leaning backwards, weight baring on the heel and protrusion of the mandible. ('Lucky Luke' or Angle Class III) The anterior type (2) leaning forward has weight baring on the forefoot and a retraction of the mandible. ('Bugs Bunny' or Angle Class II). Perillo et al. (2001) failed to find a co-relationship with posture and occlusion based on this idea but variations on what defines anterior and posterior posture could be the cause. They found posture to be more closely associated with regions than occlusion.



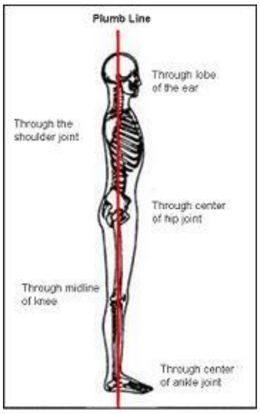


Figure 18. Anterior/Posterior Posture and Neutral

Figure 19. Neutral posture

Source: google pictures

3.8 The Meersseman Test

The Meersseman Test appears in literature in the medical fields of Physiotherapy (von Piekartz, 2005), Osteopathy (Liem, 2003), (Schleupen et al. 2010), (Corts, 2011), Orthodontics (Entrup, Manuelle Medizin, 2004), Ear, Nose and Throat (ENT) (Hülse et al., Manuelle Medizin, Vol. 40, 2002) and mentioned in numerous interdisciplinary studies (Köneke et al. 2010, CMD, Interdisciplinary Diagnostic and Therapy).

The test has its origins in Kinesiology (Dr. J.P. Meersseman, Chiropraktiker and Kinesiologist) but now appears in variations as a diagnostic tool in the in present day osteopathic education in Europe, e.g. the Wiener Schule für Osteopathie (WSO) as well as in further education courses. As part of the growing interest in interdisciplinary work and research into the co-relationship of occlusion and posture, the test has become more well-known and often not referred to by its original name. The test now seems to be established in Osteopathy even if there is a lack of supporting research. The results of the test can help

Osteopaths decide what role occlusion and/or Jaw dysfunction plays in the treatment plan for patients.

Corts (2011) describes the test being used to distinguish between different causes of a sacroiliac joint dysfunction as well as ascending and descending myofascial chains. Von Piekartz describes the Meersseman Test being used to assess whether the Temporomandibular Joint influences an identified positive standing flexion test and therefore be seen as the primary problem.

The patient is asked to bite on dental rolls placed between the molars on each side of the mouth. The patient then bites, swallows and walks on the spot. This procedure was also used in our study. If the test is positive, the identified positive standing flexion test should change to negative. The body apparently changes its neuromuscular facial system due to the change conditions of the jaw. Changes to the range of motion of the cervical spine is another parameter that is commonly assessed with the test.

Von Piekartz uses the Patrick-Kubis hip abduction Test under similar conditions to assess TMJ dysfunction. He also uses 1-4 layers of normal sheet paper between the teeth. If the hip abduction improves by at least 15 °, a Temporo-Mandibular Dysfunction (TMD) is highly likely. Von Piekartz sees the test useful for dentists to assess if manual therapy or osteopathic treatment should be applied before fitting a dental guard or brace. The test should be repeated later to make sure the TMD is not just a result of primary cervical dysfunction.

4 Research Question and Hypotheses

Research Question

Is there a Difference in the Range of Cervical Motion between People with an Overbite and People with a Normal Occlusion?

Hypotheses

Null Hypothesis 1

There is no difference in the range of cervical motion of subjects with an overbite compared to subjects with normal occlusion.

Alternative Hypothesis 1

There is a difference in the range of cervical motion of subjects with an overbite compared to subjects with normal occlusion after biting on dental rolls. .

Null Hypothesis 2

There is no difference in the range of cervical motion between subjects with an overbite and subjects with normal occlusion after biting on dental rolls.

Alternative Hypothesis 2

There is a difference in the range of cervical motion between subjects with an overbite and subjects with normal occlusion after biting on dental rolls.

5 Test Structure

A test group and a control group of participants were organized based on strict criteria to participate in a two by two comparative research trial. Both groups were to be mixed at the trial and measured in the same procedure detailed later. Apart from the trial organizers and the dental professionals consulted, nobody was aware of the exact intention of the trial. Parents and children were not aware that they belonged to a group but were given a basic guide to the tests in order to motivate voluntary participation and parental approval.

After careful consultation with a number of Orthodontists and Dentists, two groups of 21 children between the age of 10 and 17 were recruited. This age group was used in order to increase comparability and avoid difficult age related factors such as trauma, arthritis and aging of teeth and bones. With the permission of the relevant parents, the dental records were used to select children with an obvious overbite and others with no evidence of an overbite or a treated overbite. For the purpose of the study there was no clear distinction made between overbite with or without overjet as both deviations often come together and are closely related. Some of the test participants were receiving orthodontic treatment and they were only accepted if they were not wearing bands that affected the position or function of the mandible. With the high prevalence of orthodontic treatment in Germany, it would otherwise be impossible to find a sufficient number of participants. It was also quite possible that the control participants could have had minor occlusion deviations as perfect occlusion is very difficult to find.

Test Group:

- a clearly identifiable Angle Class II overbite with or without over-jet
- fixed orthodontic braces were accepted but without rubbers or similar devices affecting the movement and position of the mandible and TMJ
- adolescents between the age of 10 and 17
- no history of injury to the spine and in particular the neck
- no history of neurological conditions effecting motor control
- able to understand and carry out the commands of the test
- voluntary participation
- parental approval

Control Group:

- an occlusion that is considered by the Dentist and Orthodontist to be normal and not requiring any correction or medical intervention
- an occlusion that has no apparent cross-bite, over-bite, under-bite, open-bite
- an overbite was never identified or treated
- no pain in the jaw
- no history of serious injury to the spine and in particular the neck
- no history of neurological conditions effecting motor control
- able to understand and carry out the commands of the test
- voluntary participation
- parental approval

The Test:

The trial was divided into two parts and carried out identically with all 42 participants. In the first part of the test the cervical mobility was measured in a sitting position. This included maximum extension and flexion of the neck, followed by maximum side-bending and maximum rotation to the left and right according to the protocol and recorded with the Zebris three dimensional ultrasound device.

The second part of the trial involved repeating the test with an intervention. The participants were requested to bite moderately on two dental rolls placed between the teeth, one on each side and then to stand up, walk on the spot and swallow a few times. While maintaining a moderate bite on the dental rolls, the maximum flexion, extension side-bending and rotation in the sitting position were measured again. This intervention was selected as a way of changing the position and tension around the Temporal-Mandibular Joint (TMJ) for a short period of time.

6 Measurement and Gold Standard

The best manual measurement devise for the range of movement for the cervical spine is an inclinometer, giving measurement in degrees. The range of movement (ROM) is seen in degrees and relates to two fixed points, one being the inclinator on the head and the other at shoulder level.

Figure 20. Inclinometer, 3D Ultrasound Recorder and Report, Source: Zebris

Malmström, Karlberg, Melander and Magnusson (2003) in their study "Zebris Versus Myrin: A Comparative Study Between a Three-Dimensional Ultrasound Movement Analysis and an Inclinometer/Compass Method: Intra-device Reliability, Concurrent Validity, Inter-tester Comparison, Intra-tester Reliability, and Intra-individual Variability" looked at the two devices for measuring cervical range of motion. They used sixty volunteers who performed active maximal movements in flexion–extension, rotation, and lateral flexion. Maximum cervical range of motion was recorded simultaneously with the Zebris and a Myrin gravity-reference goniometer. Intra-device reliability, concurrent validity, inter-tester comparison, intra-tester reliability, and intra-individual variability were computed. Their study showed good agreement of full-cycle cervical range of motion measurement between devices, testers, and the test and retest (intra-class correlation [ICC] was >0.90 for intra-device reliability, >0.93 for concurrent validity, and >0.92 for intra-tester reliability). Method error, assessed with the within-subject coefficient of variation for 95% of the measurements, was 5.4% to 11.1% for intra-device reliability, 4.4% to 7.6% for concurrent validity, 3.6% to 7.6% for intra-tester reliability, and 5.3% to 9.9% for individual variability. Individual variability did not increase with an increased cervical range of motion. They concluded that both devices are reliable and showed good agreement and that the two techniques can be used interchangeably.

The Zebris software records and produces a live movement analysis of the head movements graphically in degrees and real time. The following is an example of a Zebris report.

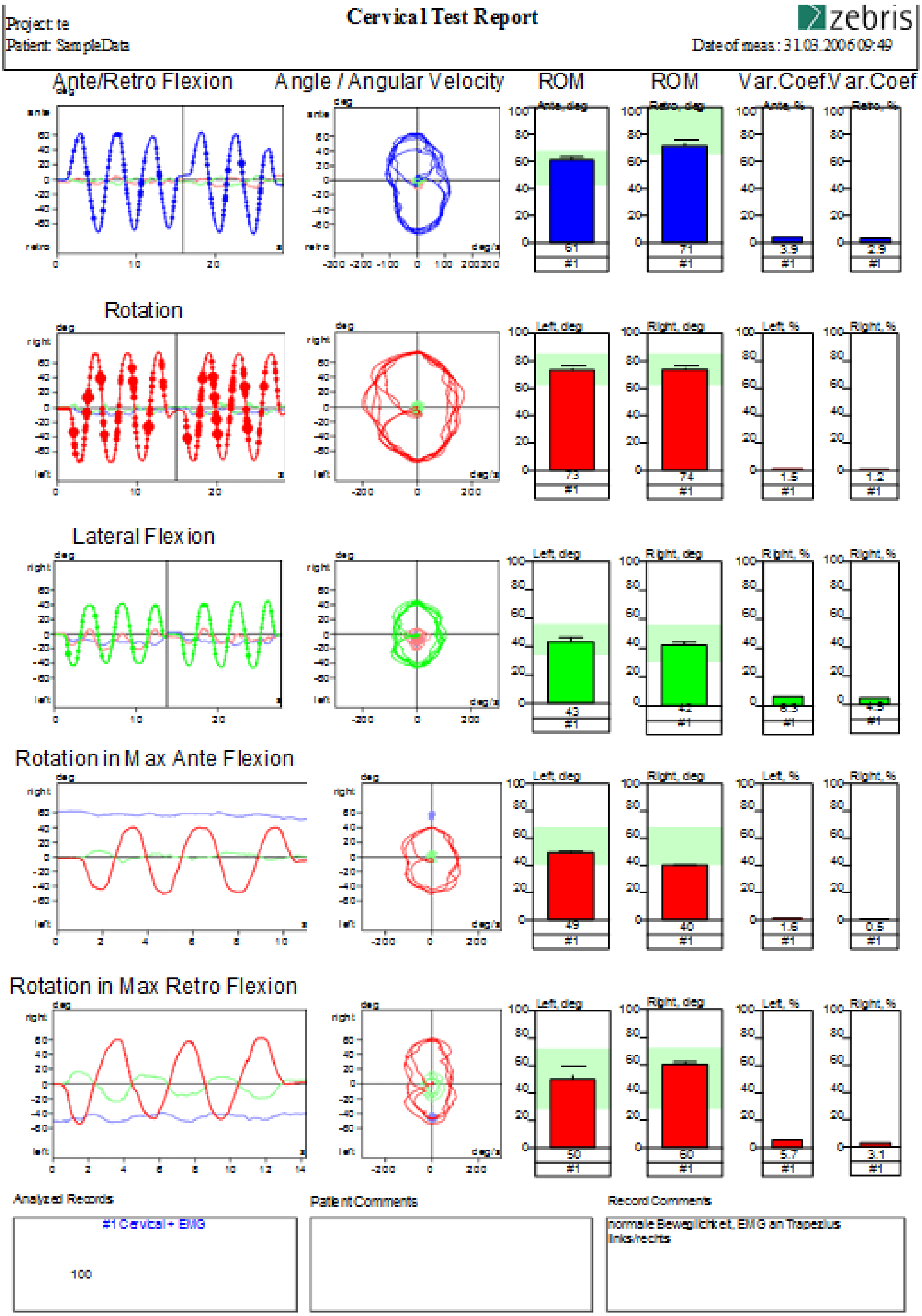


Figure 21. Sample Report, Zebris

Standard values used for the variables measured by the original program from 2000 (Winspine 1.36) were taken from Youdas et al. (1992) Trott et al. (1996), Dvorak et al. (1992), Feipel et al. (1999), and Lantz et al. (1999), and serve as reference values for the software. Positive references to the validity and reliability were made by Gracovetsky et al. (1989), Bulgheroni et al. (1998), Smolenski et al. (1998) and Schreiber et al. (1997).

The program stores a unique data set containing the measurements made by each participant. A results protocol is created for these measurements which provides data on the extent of movement in degrees (flexion, extension, rotation, lateral flexion, rotation in maximum flexion and extension) plus the speed of the movement. In this study, the last two values were not used. The program then calculates mean values for speeds and extent of movement. There is also an indication of the subjects ability to coordinate movements.

Wang et al. (2002) made similar findings comparing the ranges of cervical motion measured by gravity-based goniometry and the Zebris device. Prushansky et al. (2010) examined the validity of the digital inclinometer using the Zebris device.

7 Test Procedure

The measurements took place over a period of 11 days at the same place and conditions. The participants were ordered in no order and they and the operator of the Zebris device were not aware that there were two groups. The operator was given the task to carry out the measurements according to the protocol and collect the data. The assistant communicated with the participant to carry out the commands for the test.

Upon arrival the participant's details were taken and then the test procedure was explained in detail followed by an introduction to the measuring device. The participants were seated on a chair with no back and positioned so the assistant was directly in front. The sitting position was explained in detail which included placement of the feet (floor contact and under the knees), position on the chair, placement of hands (on the thighs), direction of the eyes (the instructor), position of the shoulders (neutral) and angle of the back (neutral and upright). Care was taken that the ultra sound reference marker, strapped the participant's back, did not excessively move, although the ZEBRIS program takes this into account. The 'dry run' involved going through the complete motions and repetitions of the test. For example the command in German for rotation was:

"Turn your head as far as possible slowly and evenly to the right, now to the left, the right again, the left again, right again, last turn to the left and back to the middle looking at me."

Later during the measurement phase, rotation for example, was repeated as above and again at the end with the intervention. The final value for the first part of the test for comparative rotation LEFT before the intervention is the average of three turns to the left.

The procedure

Part 1:

- instructions as to the correct sitting position , placement of the hands plus head and eye position
- dry run of the test including the order and correct number of repetitions
- placement of the test equipment
- testing the stability of the equipment
- testing the reception of the equipment
- test carried out with assistant commands

Part 2

- dental rolls are placed in the mouth between the teeth and held with a moderate bite
- the participants stands up, walks on the spot for one minute and swallows at 30 and 60 seconds
- participant returns to the correct sitting position and maintains the moderate bite on the dental roles
- the test is carried out exactly as before
- data in the form of a graphic report with values is produced (see example)

Figure 22. Test person with Zebris 3D Ultrasound Device

Figure 23. Dental Rolls

8 <u>Data Collection and Results</u>

The relevant data was collected from the ZEBRIS program and later transferred to an Excel worksheet. This data was then assessed by Dr. Adalbert Wilhelm for its statistical relevance. This is based on the group size and the actual results shown in the following graphs.

RAW DATA

			L/R	L/R		L/R	L/R		
PatientID	Group	ExtensionFlexionPre	LateralFlexionPre	RotationPre	ExtensionFlexionPos	LateralFlexionPos	RotationPost	Geschlecht	Alter
1	Test	83 76	38 41	71 73	78 74	40 41	70 73	W	13
2	Test	82 44	37 34	63 68	78 49	38 32	59 61	w	14
3	Test	28 28	37 40	67 65	33 87	48 45	70 67	w	14
4	Test	76 84	40 35	94 62	62 81	38 29	83 67	w	16
5	Test	66 91	38 39	84 86	64 86	43 39	90 77	m	11
6	Test	74 87	46 48	80 77	69 82	46 49	87 73	m	11
7	Test	28 79	29 34	58 45	40 82	44 43	68 62	w	10
8	Test	59 72	28 17	76 54	60 71	29 20	72 51	m	15
9	Test	55 55	29 37	69 65	51 57	31 36	70 63	m	16
10	Test	64 59	34 36	81 82	73 61	37 38	86 79	M	14
11	Test	26 59	26 25	52 45	52 62	25 32	65 52	W	14
12	Test	96 55	45 43	82 77	75 70	49 40	79 77	W	11
13	Test	65 73	42 35	81 66	61 79	43 40	79 76	M	12
14	Test	78 50	36 38	71 76	71 61	40 34	72 71	M	10
15	Test	76 71	44 41	81 75	79 78	43 45	81 78	W	11
16	Test	79 67	44 39	73 60	69 64	44 40	70 68	W	15
17	Test	60 72	31 30	75 67	62 64	28 29	78 63	M	12
18	Test	37 68	22 31	60 31	43 73	28 28	72 67	M	16
19	Test	33 85	22 28	49 71	36 78	29 29	75 59	M	11
20	Test	43 71	38 33	66 63	47 62	39 41	60 59	W	11
21	Test	73 65	29 37	80 76	65 67	30 39	79 18	M	13
22	Control	66 54	48 43	82 73	64 52	43 44	77 77	m	16
23	Control	84 84	66 55	92 84	86 73	53 54	87 81	w	17
24	Control	87 62	42 49	82 79	90 66	48 46	76 79	w	15
25	Control	63 63	44 41	72 75	63 63	42 43	73 72	w	16
26	Control	57 79	45 46	86 80	56 76	46 50	91 81	m	16
27	Control	62 77	51 55	81 69	60 78	51 55	83 78	m	15
28	Control	67 70	42 44	84 67	67 75	45 45	86 70	m	17
29	Control	70 60	47 52	73 80	68 64	51 54	75 75	w	16
30	Control	79 82	50 41	88 80	83 79	44 41	83 85	w	15
31	Control	82 81	44 42	82 79	85 78	44 38	74 76	m	14
32	Control	65 81	43 37	86 74	70 79	47 43	77 76	M	16
33	Control	76 78	47 52	84 81	72 71	48 52	74 81	M	16
34	Control	72 62	40 40	79 80	66 65	44 43	77 72	M	14
35	Control	88 62	52 46	93 81	85 57	50 51	86 87	M	15
36	Control	106 66	62 48	94 86	107 55	55 49	82 93	W	15
37	Control	82 87	52 54	87 92	88 75	55 57	89 90	M	14
38	Control	69 53	50 53	84 75	75 54	51 52	78 73	W	15
39	Control	86 57	37 33	71 67	86 53	33 35	67 66	W	10
40	Control	94 63	64 54	88 76	91 64	60 54	88 77	W	16
41	Control	86 77	63 56	100 86	83 83	65 57	97 92	W	15
42	Control	84 72	43 51	75 83	80 65	41 45	74 79	W	14

Table 2 Raw data

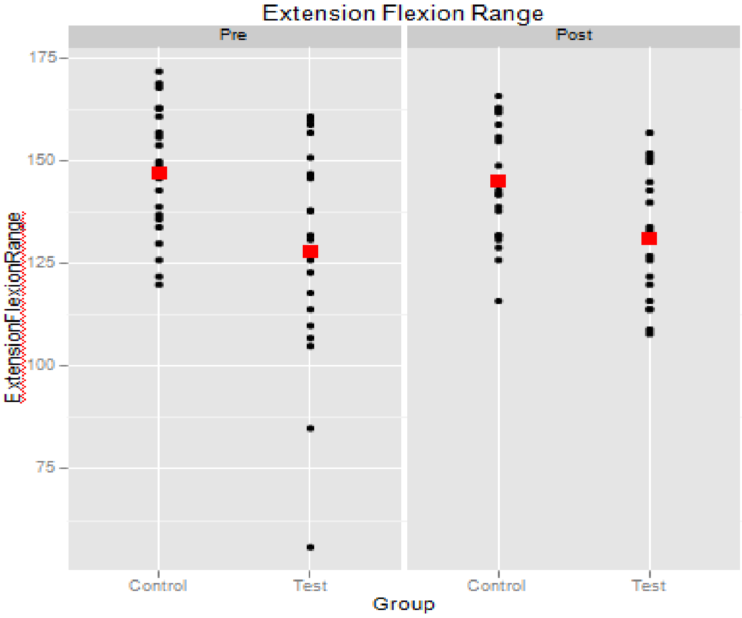
Part 1

The control and test groups were assessed based on total range and difference between two opposing movements. The Range is the sum of flexion and extension, lateral flexion right and left, rotation right and left. The difference is the absolute value of the movement back and forward or left and right.

Based on the data collected, the difference between test and control group in Part 1 according to Dr. Wilhelm, is statistically significant at the 0.1% level for all parameters measured, i.e. extension - flexion range, lateral flexion range and rotation range. The results are shown in the first column of the following six graphs.

Part 2

The effect of the intervention can be seen when the first column is compared to the second column. There is a tendency for a statistical significant difference between control and test group for rotation difference. The intervention effect (difference between pre and post measurements, notated by variable time) is also significant at the 5% level for lateral flexion differences. There would appear to be little change to the ROM after the intervention. The difference between the values was examined as it gives an indication to the change of symmetry. General symmetry between left and right would normally be expected but not perfect symmetry. Between the back and forward movement, symmetry would not be expected as these movements are fundamentally different even if they are connected.

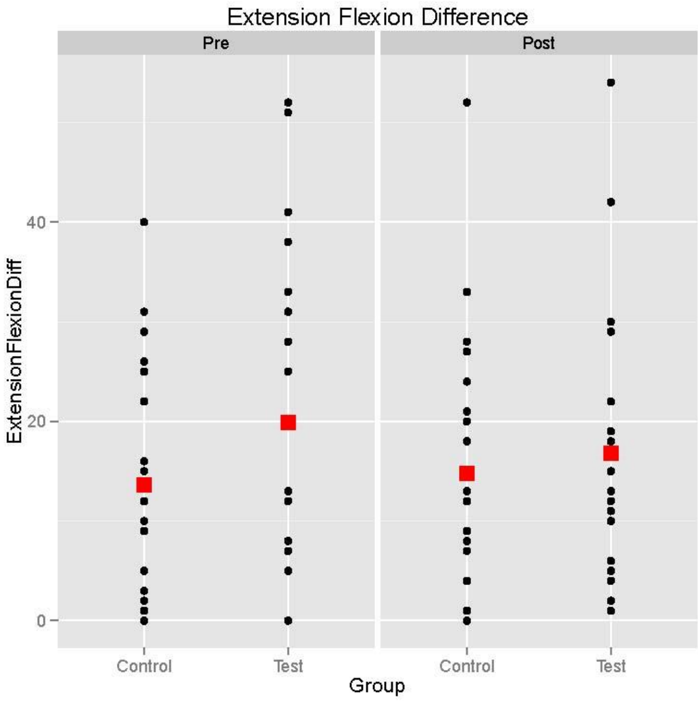



```
                Df  Sum Sq  Mean Sq  F value    Pr(>F)
Group            1    5783     5783   16.870  9.51e-05 ***
time             1       4        4    0.013     0.911
Residuals       81   27769      343
---
Signif. codes:   0 ÄY***ÄZ 0.001 ÄY**ÄZ 0.01 ÄY*ÄZ 0.05 ÄY.ÄZ 0.1 ÄY ÄZ 1
```

Figure 24: Extension-Flexion Range

The red squares in the plots indicate the group means. The range, that is, the sum of extension and flexion is shown here and there is a clear difference to be seen between the groups. The intervention on the other hand shows little influence on the values. The control group even shows minimal reductions in the range following the intervention.

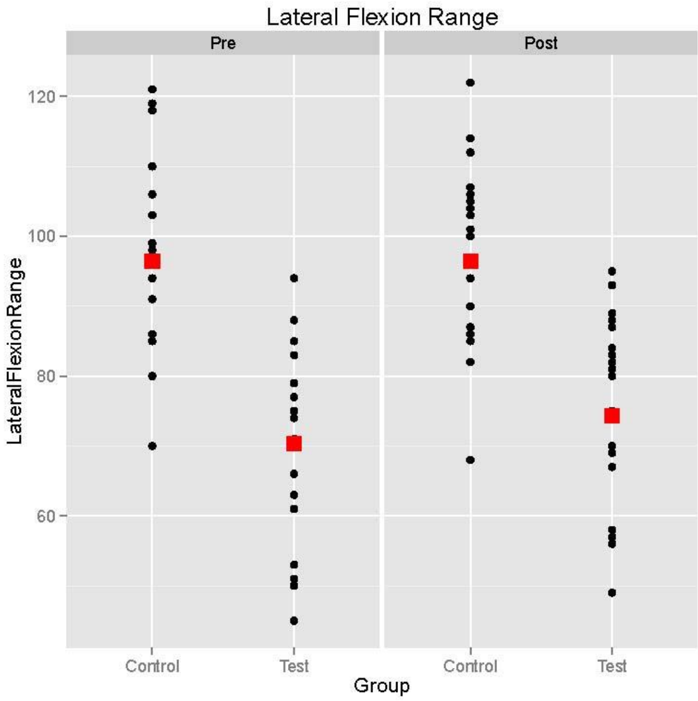
The average range in degrees of the control group for extension was 77.4 and flexion 70. The average range in degrees of the test group for extension was 61 and flexion 67.2.



	Df	Sum S	Mean Sq	F Value	Pr(>F)
Group	1	356	356.3	1.825	0.180
Time	1	22	22.0	0.113	0.738
Residuals	81	15812	195.2		

Figure 25. Extension-Flexion Difference

The difference represents the absolute value of difference between the movement of the head and neck back and forward. As flexion and extension are two different movements, it would not be expected that they appear symmetrical. Youdas et al. found that extension range in normal healthy individuals is larger than the flexion range and that is the case for the control group and not the test group.

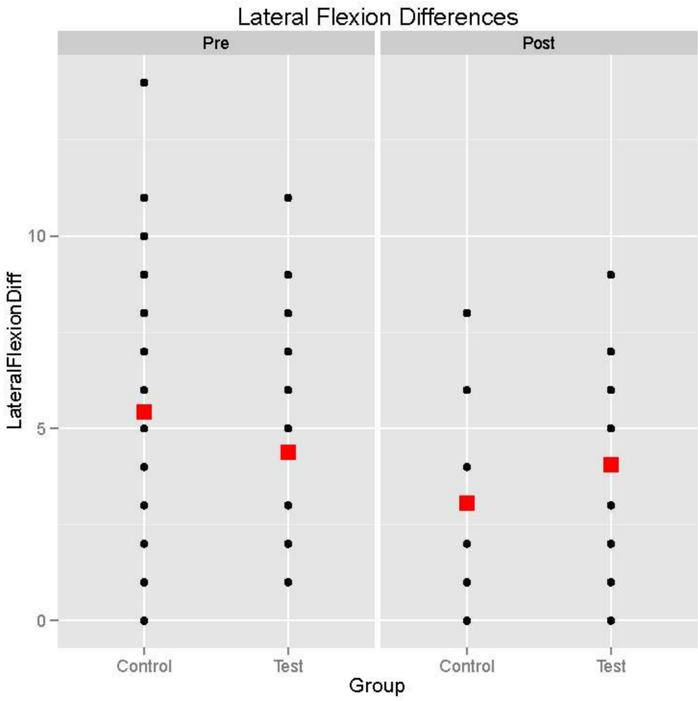


	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Group	1	12168	12168	69.838	1.48e-12 ***
Time	1	86	86	0.494	0.484
Residuals	81	14113	174		

Signif. Codes 0 *** 0.001 ** 0.01 * 0.05 0.1 1

Figure 26. Lateral Flexion Range

The red squares represent the group means. The average range in degrees of the control group for lateral flexion left was 49.1 and right 47.2. The average range in degrees of the test group for lateral flexion left was 35 and right 35.5.



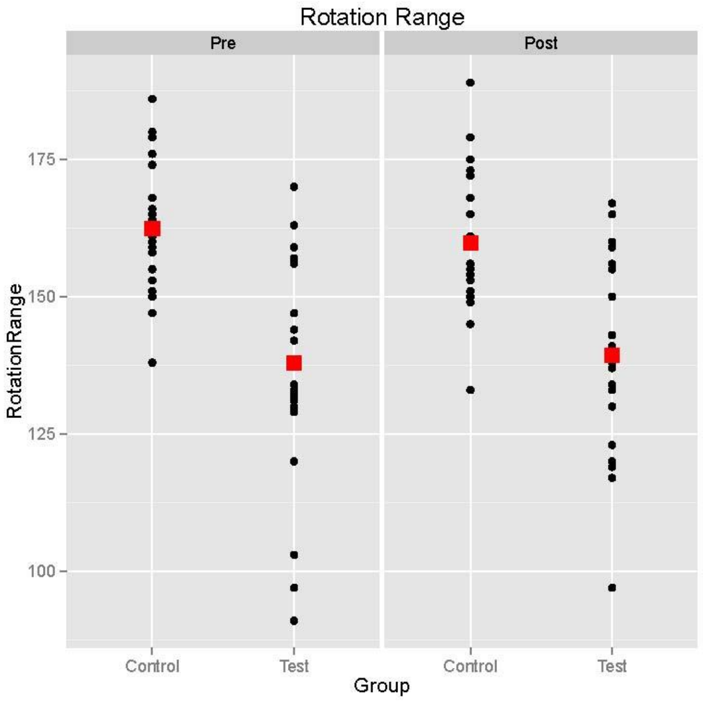
	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Group	1	0.0	0.01	0.001	0.9711
Time	1	38.7	38.68	4.292	0.0415 *
Residuals	81	730.0	9.01		

Signif. Codes: 0 *** 0.001 ** 0.01 * 0.05 0.1 1

Figure 27. Lateral Flexion Difference

The intervention effect (difference between pre and post measurements, notated by variable time) is significant at the 5 % level for lateral flexion differences and is marked by one star by the significance codes.

The difference is between left and right and the change is negative in both cases. The intervention would appear to balance out inequalities more in the Control group.

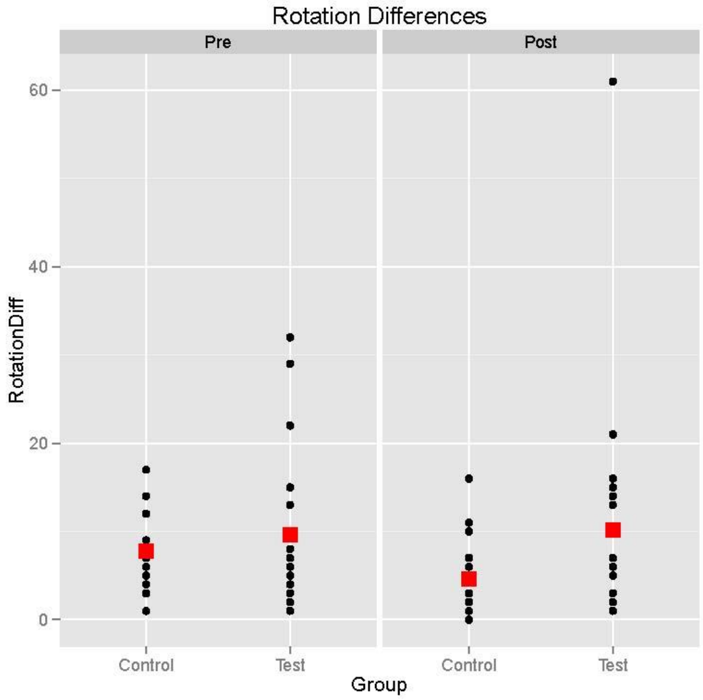


	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Group	1	10541	10541	38.600	2.12e-08 ***
Time	1	9	9	0.032	0.859
Residuals	81	22121	273		

Signif. codes: 0 ***.. 0.001 **.. 0.01 * 0.05 0.1 1

Figure 28. Rotation Range

The average range in degrees of the control group for rotation left was 84 and right 78.4. The average range in degrees of the test group for rotation left was 72 and right 62.



	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Group	1	286	286.01	3.870	0.0526 .
Time	1	36	36.01	0.487	0.4871
Residuals	81	5986	73.91		

Signif. Codes: 0 *** 0.001 ** 0.01 * 0.,5 0.1 1

Figure 29. Rotation Difference

There is a tendency for a statistical significant difference between control and test group for rotation difference. The difference is between left and right. The intervention would appear to balance out inequalities and in this case more in the Control group.

Average Values in Degrees	TEST Group	CONTROL Group
EXTENTION PRE	61.0	77.4
FLEXION PRE	67.2	70.0
LATERAL FLEX Left PRE	35.0	49.1
LATERAL FLEX Right PRE	35.3	47.2
ROTATION Left PRE	72.0	84.0
ROTATION Right PRE	62.0	78.4
EXTENTION POST	60.0	77.4
FLEXION POST	70.8	67.8
LATERAL FLEX Left POST	37.7	48.4
LATERAL FLEX Right POST	36.6	48.0
ROTATION Left POST	74.5	76.9
ROTATION Right POST	64.8	79.0

Table 3. Average Values

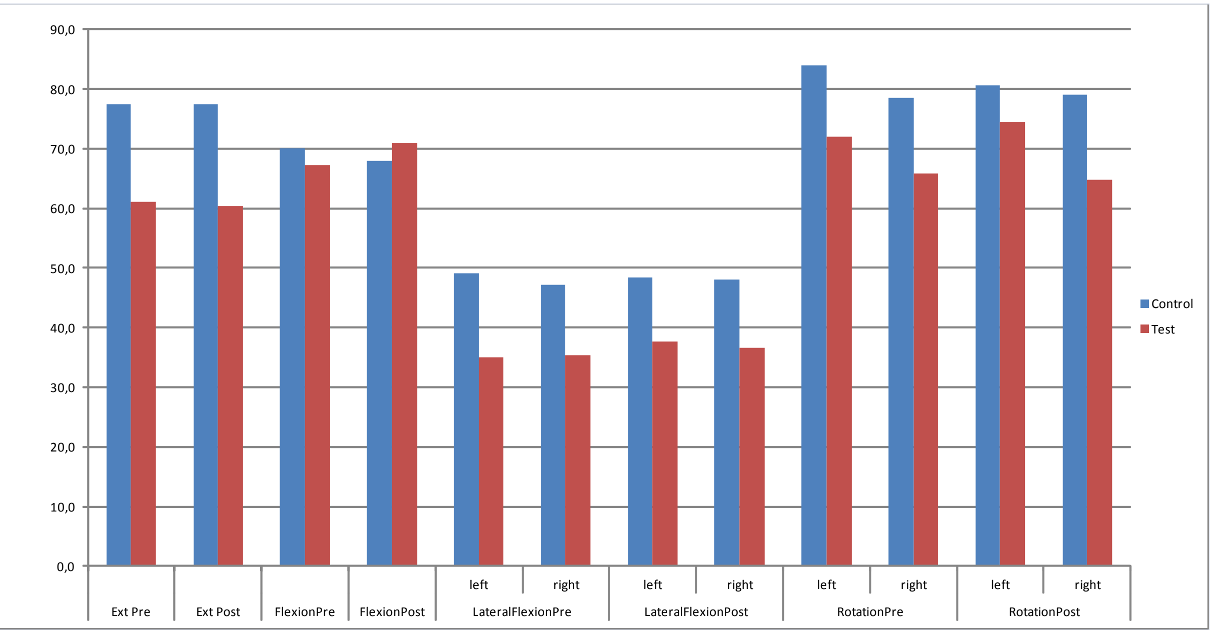


Figure 30. Comparison of Test and Control Groups in Part 1 and in Part 2

9 <u>Discussion</u>

Part 1

The results show a significant difference between the groups in the parameters extension, rotation and lateral flexion and one can conclude that the control group has a greater active ROM. The flexion ROM of the control group was the only parameter which was not substantially larger than the test group. This is not apparent when the total ROM from the head moving back and forward is presented and this may reflect the difficulty in finding the true neutral or zero point. Although great care was taken in selecting the participants, small variations in occlusion could be found in both groups. This could account for the variations in differences. While testing for maximum active range, it was important to avoid compensatory movements and at the same time reach the maximum range of movement. Other important factors here are whether the participants are confident in what they are doing. Younger participants theoretically have a larger ROM but are not as confident in carrying out commands. Some participants will try to maximize their AROM and others are hesitant. When is motion really at an end? Do we all understand what maximum movement is without pain and can we do this numerous times? The dry-run of the test before the measurements were taken was intended to warm-up the muscles and practice the task. The measured value from the ZEBRIS device was the average of three identical actions. This means the subject turned their head for example to the left and then the right three times. The average of the three measurements to e.g. the left was calculated. The complete task was done as a warm-up, first measurement and then the second measurement. The concentration is important with so many repetitions. There was no attempt to use multiple testers for the purpose of inter-tester reliability which would have been important if an inclinometer had been used.

The results imply that there are many clinical implications for Osteopaths, particularly those treating children. If occlusion interacts with cervical motion, it is quite likely that cervical motion interacts with occlusion. This has been examined in many other studies, for example, the subject of whiplash related injuries and postural variations. It also indicates that osteopathic treatment of the TMJ may have wider ranging effects on the cervical spine and therefore, indirectly on posture.

Part 2

There had been much discussion as to the nature of the intervention. Numerous other objects could have been used instead of dental rolls. Many may question what the intervention actually does but the intention was to cause a slight gapping of the TMJ, changing its position and balancing out the tension of the muscular and ligaments. Some of the participants probably bit harder than others as this was very difficult to standardize. This will cause variations in the tension of the muscular around the joint and possibly of the upper cervical spine. This is only a short-term intervention in contrast to, for example, wearing a brace or brackets for months, dental work effecting height and sucking of the thumb. The change over from primary to secondary or permanent teeth also causes changes to the position of the developing jaw in the medium and long-term. Klemm concluded that (very) short-term changes to occlusion do not appear to change the AROM as is the case here. The changes in difference for left and right possibly indicate that the intervention has a small balancing out effect. Why the Control group reacted better to the intervention can only be speculated. This was not a test of the Meersseman Test but there was an intention to research the relevance of its use in the practice. It seems questionable that the test is reliable considering that it is used with numerous malocclusion forms with diverse complicating factors and an open age range.

10 Conclusions

Based on the Hypotheses presented, the following questions need to be answered.

PART1: *Are there differences in the mobility of the neck between the control group and the test group?*

PART 2: *Does the intervention used in both groups influence the mobility of the cervical spine?*

In reference to Part 1, it would appear that the active range of movement (AROM) in the control group is statistically better than in the Test group for extension-flexion, lateral flexion and rotation at a level of 0.1%. The results indicate that the average Active Range of Motion (AROM) of the cervical spine in flexion, extension, lateral flexion and rotation of individuals with an overbite is smaller than the average AROM of individuals with a normal occlusion. Based on the data presented, the difference between the two groups is statistically significant at the 0.1% level.

The intervention had little positive or negative influence over the active range of movement (AROM) for flexion-extension, rotation and lateral flexion of both the Test and Control group. The intervention appears to have had little statistical effect on the difference of flexion-extension except for a negligible positive change for the Test group. For lateral flexion there is a 5% statistical difference for the Control group and there is a tendency for a statistical difference for the rotation values for the Control group. Youdas et al. also documented normal variations in differences left and right. It is rare to find symmetric values but the differences are minimal. What is interesting is that they also found that the normal range of extension to be greater than the normal range of flexion. This was the case with the Control group. The effect of biting and holding dental rolls between the teeth for a short period of time would appear not to influence the AROM but possibility influence symmetry of movement by balancing out movements from left to right in the parameters of lateral flexion and rotation. In the study the Control group reacted in this sense better to the intervention than the Test Group.

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12 Figures and Tables

Tables: