Symptoms and signs of temporomandibular disorders in children and adolescents, before and after orthodontic treatment.

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SYMPTOMS AND SIGNS OF TEMPOROMANDIBULAR DISORDERS IN CHILDREN AND ADOLESCENTS BEFORE AND AFTER ORTHODONTIC TREATMENT

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DECLARATION

I declare that “Symptoms and signs of TMD in children and adolescents before and after orthodontic treatment” is my own work, and that it has not been submitted for any degree or examination in any other university.

All the sources used are indicated as complete references.

Maria Espinós Solans Date: June 2017. Signed: 

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DEDICATION:

To my mother, who transmitted me the passion for orthodontics.

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Abbreviations

TMD: Temporomandibular disorders

TJ/ TMJ: Temporomandibular joint

MRI: Magnetic Resonance

MFA: Manual Functional Analysis

KIG: Kieferothopaedischer Indikationsgruppen

1. Introduction

CHAPTER 1

INTRODUCTION

As one of the fathers of occlusion once said “It is realistic to assume that the more complex a system is, the bigger the probability is that a problem can occur. It’s remarkable to think that in most of the situations, the mastication system works without big problems within a person’s life. But otherwise, if a problem occurs, it can involve such a complicated situation as the system itself”.[1]

In orthodontics, because the temporomandibular joint is said to be really difficult to understand and to treat, it seems like somehow its anatomy and diagnostic tends to be ignored by many professionals.[2] However, the importance of an accurate knowledge of the craneomandibular structures, as well as an accurate knowledge of the biomechanics of the masticatory system is for dental and orthodontic clinicians essential.

Nevertheless, and because of the great number of signs and symptoms that can occur within the canio-facial system, it has stimulated many specialists to deepen in this subject and it has generated a big volume of scientific literature related to epidemiology, aetiology, and clinical, psychological and therapeutic aspects, related to the young and adult patient.

Most of the studies in the literature related to temporomandibular joint disorders, have been done in adult patients, but its important to notice that a certain number of studies have also shown that functional disturbances in children an adolescents are also common [3] and that is the reason why we want to study the prevalence and the influence of the orthodontic treatment in children from one of our Orthodontic Offices more accurately.

Classically temporomandibular joint disorders had been considered an adult pathology but now a few studies reflect that their origin could be in younger years and that occlusal disharmonies and orthodontic treatment could be risk

factors. Signs and symptoms in children and adolescents happen in a lower percentage than in adults and its diagnosis is not simple, because of the difficult interpretation of their symptoms, that are described in many of the cases by the parents in a not so accurate and subjective way. It happens to also be confused by paediatricians with ear, nose, and throat pathology.

Although Magnetic Resonance (MRI) has become a standard procedure in the diagnosis of temporomandibular joint disorders (TMD), clinical functional analyses have not lost their importance, primarily because due to finantial and technical reasons, it is often impossible to apply MRI in everyday practice. Furthermore, the research by Widmalm et al. stated that diagnosis of TMD on the basis of MRI protocols made by a single examiner should not be accepted as a standard criterion with regard to TMD.[4] These arguments encouraged the choice of clinical manual function analysis according to Bumann and Groot Landeweer as the examination procedure on children and adolescents in this study.[5]

Many of the diagnosis methods for temporomandibular joint disorders, from axiography, electromyography measures, to the high developed magnetic resonance, digital volume tomography,… need as well as a long time, a lot of money what most of our patients can not afford. They also concentrate themselves in the diagnosis of concrete parts or concrete structures and that is the reason why they can not be used as standard diagnosis methods, even though in unclear cases it is of course necessary.

It was not until 1989 when A. Bumann et al., designed a daily office examination adapted method, based on orthopaedic exploration techniques already described by Cyriax, Maitland, Menell and other clinicians years before: the Manual Functional Analysis. The Manual Functional Analysis by Bumann and Groot Landeweer' (MFA) is a group of manual examination techniques by which the causes of temporomandibular joint disturbances are differentiated and tissue-specific diagnosis are given.[6] To make it easier for the every day practice Dr. Axel Bumann designed, in order to shorten and lighten the most important points of the whole Manual Functional Analysis, the so called Routine Examination Protocol (Boston 1999). The Routine Examination Protocol is a

reduced version of the complete Manual Functional Analysis and it is the one we will be using throughout this study. It comprises orthopaedic test procedures that examine the incidence, intensity and time of development of clinical signs of TMD using specific techniques of loading the structures within the joint capsule.[6]

Lobbezoo-Scholte et al. have already shown the diagnostic value of orthopaedic tests in the TMD diagnostics.[7,8] Bumann and Zaboulas proved the validity and reliability of manual functional analysis by comparison of the MRI results and the manual functional analysis results of their study. A correspondence of the results was found in 80% to 94% of the subjects.[9]

As this reliable and validated functional analysis method is non-invasive, radiation-free and with no cost for the patient, we considered it a very interesting and above all, a realistic option in order to examine the children and adolescents before and after an orthodontic treatment. It is important to notice that no Scanners or Magnetic Resonances of the temporomandibular joints are covered by the Public Dental Service in order to make an orthodontic diagnosis.

MFA provides a validated overall system to diagnose TMD and has been used for the examination of young adults10 and adult patients in many studies[10-17], but it has not still been used in studies with children or adolescents. However, provocation by specific clinical procedures is a very important part of diagnostics and is particularly stressed in recent studies which used MFA.[10-14] Furthermore, MFA use has been recommended as a screening test for symptoms and signs of TMD before orthodontic treatment.[10,15]

The objective information we dispose about children is low, a reason why we need more research in this field, in order to achieve a better approach to preventive and, if needed, therapeutical treatment of the craneomandibular disorders.

This study allows the possibility to check the temporomandibular joint status pre and post orthodontic treatment with a validated irradiation free technique which can be performed by trained orthodontists.

To date, there is no published data on the role of orthodontics and temporomandibular dysfunction, using Bumann's Manual Functional Analysis as an examination method for children and adolescents, comparing the results of this examination, before and after an orthodontic treatment, and this is what this study hopes to address.

The aim of this study is to follow longitudinally the signs and symptoms of temporomandibular disorders in children and adolescent patients seeking orthodontic treatment, comparing the previous results with the ones obtained once their orthodontic treatments are finished, by means of a validated functional manual technique.

Our objective is to clarify if our orthodontic treatments can affect the joint situation of young patients' with malocclusion, a question which is still being debated in professional circles.

Furthermore, we hope to prove the importance of an accurate diagnosis of temporomandibular disorders in the orthodontic practice, which would not only be an advantage for the patient but also for the clinicians.

2. Aims and objectives

CHAPTER 2

AIMS AND OBJECTIVES

2.1. Aim of the study

The aim of this study is to follow longitudinally the signs and symptoms of temporomandibular disorders in children and adolescent patients seeking orthodontic treatment, comparing the previous results with the ones obtained once their orthodontic treatments are finished, by means of a validated functional manual technique.

2.2. Objectives of the study

General objective:

1. To compare the signs and symptoms of temporomandibular disorders in children and adolescents, before and after orthodontic treatment, in a selected population with moderate or severe dental malocclusions.

Specific objectives:

2. To report the frequency of TMD signs and symptoms before and after orthodontic treatment in an orthodontics office.

3. To follow the evolution of signs and symptoms of TMD longitudinally (by analyzing how many patients improved, worsened their previous status, or stayed the same, after being orthodontically treated) and to evaluate the changes in jaw eccentric movements after orthodontic treatment.

4. To study the relation between patients' characteristics, different treatment modalities and final treatment results, with the appearance of symptoms and signs of TMD.

3. Literature review

CHAPTER 3

LITERATURE REVIEW

3.1. Temporomandibular joint disorders (TMD): Definition

Over the years, the alterations of the mastication system have received many different names such as Costen's syndrome, functional temporomandibular joint disturbances, occlusomandibular disturbance, temporomandibular joint disturbances, temporomandibular joint dysfunction syndrome, myoarthropathy of the temporomandibular joint, pain-dysfunction syndrome, temporomandibular pain-dysfunction syndrome, craniomandibular syndrome and temporomandibular syndrome.

It was not until 1983 when the definitions were unified by the American Dental Association, with the name of Temporomandibular Dysfunction[18] to facilitate communication and research, which is the term we will be using throughout this thesis. Okeson defines TMD as "Functional disturbances of the masticatory System".[19] Some other researchers as Stohler[20] and Kopp[21] include in this definition masticatory muscle disorders and TMJ disk displacements under the umbrella of TMD.

Temporomandibular dysfunction is considered then, as a generic term for a number of clinical signs and symptoms involving the masticatory muscles, the temporomandibular joints (TMJs) and associated structures.[3]

3.2. History of TMD

The dental practice first started to pay attention to the TMD field in 1930, when Dr James Costen (an ear, nose, throat surgeon) published an article, based on 11 patients, where he suggested that alterations of dental occlusion may cause diverse ear symptoms.[22] After Costen's article, clinicians started to wonder about their treatments and their consequences. Between 1930 and

1940 just a few clinicians got interested about these painful problems and the most used treatment appliances were the same that Costen suggested.[23]

From 1940 the dental clinicians started to examine more accurately the appliances as an election treatment for TMD, and started to analyze if occlusal interferences could be the main aetiological factor for TMD. [24,25]

The fist serious investigations from the TMDs began in the 50s and suggested that occlusion could influence on the masticatory muscle function, and the first books about it were written.[26] In the 60s and in the 70s, it was accepted that the occlusion and the emotional tension were the main causing factors for TMD. It was then, in the late 60s, when they also started investigating the morphology of the TMJ more deeply.[27] But it wasn't until the 80s, when the dental practitioners started to identify and understand the complexity of the TMD.[28]

3.3. Epidemiology: Prevalence of symptoms/signs of TMD in epidemiological studies

According to different studies, between the 40 and 60% of the population has some type of TMD.[29] However, just round 10 % from the affected patients, present such severe symptoms or signs that are in need of a treatment.[29] In the adult patient, the prevalence of the symptoms related to TMD varies from 16 to 58% and the prevalence of signs from 33 to 44% respectively. It is considered then, to exist an average prevalence of the 30 % of symptoms and an average prevalence of signs of the 40%.[29]

Prevalence figures reported in epidemiologic studies of children are lower than in adult studies.[30] Most of the signs have been characterized as mild and often fluctuating.[30] However, a number of studies have shown that TMD in children and adolescents are common, even though severe and moderate signs and symptoms are not frequent and only a few need functional treatment.[3]

The prevalence of TMJ dysfunction in children and adolescents varies widely in the literature from 16% in children with only a primary dentition to 90% in children with a mixed dentition. Nevertheless, some of these studies are

considered inconclusive since they tend to focus on patients seeking treatment or because they were conducted for convenience on non-representative samples of the population.[30,31]

In an important study carried out by Thilander B. and colleagues, in a randomly selected Colombian children wide sample, they found that the prevalence of functional disturbances was of the 25%.[3] The prevalence was lower than in most previous publications. They explain these differences could be due to the magnitude of the samples or in the methodological registration criteria. They assure that their sample satisfies well all the requirements as they have a well defined population, the sample is large enough (4724 children) and the children were not orthodontically treated.[3] Another explanation they give is that the differences reported may be due to the different ethnic populations: similar prevalences were found in large samples of Japanese[32] and Chinese children, and supported by other well-designed studies among Swedish and Finish children.[3]

3.3.1. AGES DISTRIBUTION

One of the reasons why the prevalence of TMD in children is said to be low, could be that they rarely complain of any significant symptoms. It has been stated however, that the prevalence increases with age.[31,33-49] As the children, patients over 60 years old also complain rarely about these problems.[39]

Between the ages 20 to 40 TMJ disorders tend to occur more often.[38,39] Other studies report that these disorders tend to occur more often between the ages 40 to 50.

However, this data has a big variation, supported by one of the most recent meta-analysis[50]: 51 prevalence studies registered extreme variations of prevalence ranging from 6% to 93% based on subjects' reports and from 0% to 93% according to clinical assessments of an adult population.

Most of the studies clearly indicate that both subjective symptoms and clinical signs increase with age into adulthood. A clear example is the longitudinal collection of material performed by Egermark-Erikson et al.[41,42] in

which they recorded TMD of the same Swedish children at different ages (11, 15, and 20 years old).

Magnusson et al. investigated 119 children in a longitudinal study with a 4-year interval and reported a significant increase in signs and symptoms of TMJ dysfunction with age. The results showed that 66% of 11 and 15 year-olds had clinical signs while 62% and 66%, respectively, complained of subjective symptoms. When comparisons were made with their findings from 4 years earlier, they noticed that the subjective symptoms had increased in frequency in the younger children, while the clinical signs had increased in both groups.[37]

In another study, Magnusson et al. examined 402 Swedish patients (at the ages of 7,11 and 15 years)and found that progression to severe pain was exceptional, and 13 % of these symptoms occurred in the last exam.[51]

Other studies have also shown a difference, according to dental stages (early mixed, late mixed, young permanent dentitions). An increase from no signs to mild, moderate, and finally to severe signs in some cases was reported.[3]

3.3.2. MOST COMMON SIGNS/SYMPTOMS

The most common TMD symptoms in the adult patient are, from more frequent to less frequent, tenderness in masticatory muscles, joint sounds, joint pain, and limited mouth opening in the adult patient.[29]

One of the frequent symptoms of TMJ dysfunction is joint sounds, which don't necessarily take place together with other symptoms.[38,40] TMJ sounds are quite common and, according to Bales et al., they occur in 20% to 30% of the population, regardless of having had an orthodontic treatment or not (33).

The registration of subjective symptoms and clinical signs vary in all studies, and the patients in general, present a higher number of signs (41% to 56% respectively).[19] From all these adult patients having signs or symptoms, just round 5 % need treatment in the United States.[52]

In a study among 1940 Saudi children, the prevalence of TMJ dysfunction signs was found to be 20,7% and the most common sign of temporomandibular joint dysfunction was joint sounds (11,8%). The second most common sign was restricted mouth opening (5,3%). Muscle and temporomandibular joint (TMJ) pain as well as deviation upon jaw opening appeared infrequently. TMD symptoms as reported by the parents were evident in 24,2% of the returned questionnaires (1113). The most common symptoms were headache (13·6%) and pain on chewing (11·1%). The incidence of headache was found to be significantly increasing from primary to permanent dentition.[53]

In a large epidemiologic study of 7.337 Japanese children by Motegi and co-workers, it was found that joint sound as the only symptom was more common in younger subjects. TMD symptoms seemed more complicated with age when pain and abnormal jaw movement combined with sound. Joint sound was the most common symptom (89.3%), followed by the combination of sound and pain (2.2%). The incidence of other symptoms was under 1%. [32]

Pow et al. in their study of 1526 Chinese children (18 years old) in 2001, found 33% with mandibular pain, 5% with frequent pain, and 0,3 % mouth opening difficulty and 1,8 % joint clicking. 1 % of the sample showed moderate pain and 0,6% needed treatment for the pain, joint clicking and mouth opening difficulty.[54]

Nekora- Azak (2006) examined 1253 Turkish children (18 years old), and found a prevalence of the 35% of the patients with mandibular pain.[55]

3.3.3 GENDER SIGNS/SYMPTOMS DISTRIBUTION

In adult patients, most of the studies report symptoms to be more prevalent in females than in males. In fertile ages, TMD prevalence in women practically doubles the prevalence in men, and it reaches its maximal value between 35-45 years old.[29] However, it's important to notice that in most of the studies the vast majority of the examined patients are females.[33,38,41,43,44] That's why no significant results have been presented, and more investigation is needed in the gender field.[38,44]

In younger subjects, sex differences in prevalence of certain clinical signs were demonstrated by Thilanders et al. study [3], indicating a higher frequency for girls than boys. It is known that there are development differences in tooth eruption between girls and boys as well as between individual children. However, sex differences in prevalence of clinical signs of TMD could probably be explained by mental factors (girls tend to be more sensitive to tenderness and pain on palpation of the muscles and TMJ).[3]

Montegi et al. also found differences between girls and boys in their study among Japanese children [32], as well as Magnusson et al., who found a higher incidence of TMD in girls than in boys.[51]

Nevertheless, Farsi et al.[53] and Nekora-Azak et al.[55] did not find any significant differences between genders and to make it even more confusing, in another study, Akhter et al. (2004) examined 1200 children (12-17 years old), and found a higher incidence of TMD in boys. It is interesting to consider that they also found out that individuals from the countryside presented more joint clicking. They concluded that the suggestive symptoms of TMD were related to hard food ingestion.[56]

3.4. Etiology of TMD

The etiology of TMDs is complex and multifactorial. Numerous factors can contribute to TMDs, and research is insufficient to predict whether a patient will develop of will not develop TMD. Etiologic factors suggested as contributing to the development of TMD are:

- Trauma: Certainly, trauma to the facial structures can lead to functional disturbances in the masticatory system. Ample evidence supports this concept. Trauma seems to have a greater impact on intracapsular disorder than muscular disorders. Trauma can be divided into two general types: macrotrauma and microtrauma. Macrotrauma is considered any sudden force that can result in structural alterations, such as a direct blow to the face. Microtrauma refers to any small force that is repeatedly applied to the structures over a long period of time. Activities such as bruxism or clenching

can produce microtrauma to the tissues that are being loaded. [19] This would include impact injuries such as trauma to the chin. A common occurrence in childhood because of falling, chin trauma is reported to be a factor in the development of TMD in pediatric patients.[57-59] Unilateral and bilateral intracapsular or subcondylar fractures are the most common mandibular fractures in children. Closed reduction and prolonged immobilization can result in ankylosis.[60,61]

- Occlusal factors: The relationship of occlusal factors in TMDs is an extremely critical issue in dentistry. Some studies reflect that there is a relatively low association of occlusal factors and the development of temporomandibular disorders.[62,63] However, in other studies a relationship between occlusion and TMD is seen and they describe several features which can characterize malocclusions associated with TMD. These features are skeletal anterior open bite[3], an overjet greater than six to seven mm.[3,64-66], retrocuspal position (centric relation) to intercuspal position (centric occlusion) slides greater than 4 mm.[67], unilateral lingual cross bite,[3,64-68] five or more missing posterior teeth[69,70] and class III malocclusion.[71]

- Parafunctional habits (e.g., bruxism, clenching, hyperextension, or other repetitive habitual behaviours): Bruxism is thought to contribute to the development of TMD by joint overloading that leads to cartilage breakdown, synovial fluid alterations, and other changes within the joint. These parafunctional habits may occur while the patient is asleep or awake. A study of 854 patients younger than 17 years old found the prevalence of bruxism to be 38 percent.[72] The literature on the association between parafunction and TMD in pediatric patients is contradictory.[73-75] However, childhood parafunction was found to be a predictor of the same parafunction 20 years later.[76] Other studies found correlations between reported bruxism and TMD with a 3.4 odds ratio.[51,77] Children who grind their teeth were found to complain more often of pain and muscle tenderness when eating.[78] Farsi (2003) found a relationship between parafunctions (except bruxism) that was related to age, and considered it basic to make a signs and symptoms analysis in children.[53]

- Posture: Craniocervical posture has been associated with occlusion and with dysfunction of the TMJ, including abnormalities of the mandibular fossa, condyle, ramus, and disc.[79-81]

- Changes in “free-way” dimension of the rest position: Normally two to four mm, this may be impinged by occlusal changes, disease, muscle spasms, nervous tension, and/or restorative prosthetics.[28]

- Orthodontic treatment: Current literature does not support that the development of TMD is caused by orthodontic treatment, regardless of whether premolars were extracted before treatment.[65,82-86] We will go more in detail in a further section of this literature review.

- Deep pain imput: sources of deep pain input can cause altered muscle function. It can centrally excite the brainstem, producing protective co-contraction. This represents a normal healthy manner in which the body responds to injury or threat of injury. Any source of constant deep pain input can represent an etiologic factor that may lead to limited mouth opening and therefore clinically present as TMD. Tooth pain, sinus pain, and ear pain can create this response. Even pain sources remote to the face, such as cervical pain input, can lead to this condition.[19]

- Emotional stress: it commonly plays an important role in TMD. The patient's emotional state is largely dependent on the psychological stress being experienced. Increased levels of emotional stress experienced by the patient increase not only the tonicity of head and neck muscles but also the levels of nonfunctional muscle activity such as bruxism or tooth clenching.[19] Bonjardin et al. in their study of 217 Brazilian adolescents from 12 to 18 years old, in 2005, found a clear relationship between the prevalence of TMD and the presence of anxiety and depression.[87]

- Biochemical factors: in the last years, some authors defend that TMD are initiated because of various factors altering the viscosity and the chemical composition of the synovial fluid.[29]

- Genetic influence: recently a search has begun for a genetic influence on TMD. Researchers and clinicians are becoming increasingly aware of the possibilities that genetic variation may play a role in pain perception and onset of TMD.[88]

3.5. Orthodontics and TMD

The orthodontist has been both accused of causing and complimented for curing TMD.[89] Some of the orthodontic procedures that have received more criticism with respect to TMD are maxillary incisivi retraction with the use of headgear or elastics, and premolar extractions. Their hypothesis was based on the idea that distal pressure on the mandibular complex could put distal pressure on the condyles which could cause an anteriorly displaced disc. It was believed that premolar extractions and retraction of the anterior maxillary incisive would trap the mandible in a retruded position.[90]

Quite the contrary, since malocclusion has been by some implicated as a factor in the multifactorial etiology of TMD, it has also been suggested as a treatment modality for the prevention of some TMD.

To better understand the origin of these conflicting opinions, a review for the articles published on this field has been performed. A search in the MEDLINE data base up to the year 2014 has been made. Handsearching of Spanish, German and American orthodontic journals and other related books has been also undertaken. No language restrictions have been applied.

3.5.1. HISTORY

For many years, the main goal of orthodontics was to achieve a nivelation of the teeth, an Angle class I, and an improvement of facial aesthetics. Nevertheless, it tended to ignore its effects on the temporomandibular joint (TMJ).[91,92] However, some orthodontics specialists from the 80s, as Thompson, Graber or Rickets, are considered some of the pioneers in the studies of craneomandibular disorders.[33,93,94]

The interest of the orthodontic community was awakened abruptly in the late 1980s' following litigation that alleged that orthodontic treatment was the proximal cause of TMJ dysfunction in orthodontic patients, with substantial monetary judgments being awarded to several plaintiffs.[27,95] The outcome of these court cases resulted in a burst of research activity investigating the relationship if any between orthodontic treatment and TMJ dysfunction.[40,96]

3.5.2. THE RELATIONSHIP BETWEEN ORTHODONTICS AND TMD

In the 80s, the interest in the possible relationship between orthodontic treatments and TMD increases, blaming the orthodontic treatment for being the proximal cause of TMD in orthodontic patients. This litigious climate resulted in an increased understanding of the need for risk management as well as for methodologically sound clinical studies.[97]

From those days until now, we find many different studies, some trying to justify the absence of a relationship between orthodontics and TMD, some studies proving orthodontic treatment benefits for TMJ, some reflecting that the orthodontic treatment has a bad influence on the TMJ itself and some others considering orthodontics and its incorrect planning or results to act as a trigger for TMD or to increase its risk factor.

The situation prior to 1988 was summed up by Gianelly.[98] To the question if Orthodontics could cause TMD, Gianelly suggested that the evidence of orthodontics causing TMD was mostly based on anecdotal reports.[98] One of them was for example Roth, who only evaluated nine patients postreatment.[99]

In 1990, Reynders publishes a comprehensive review of the literature between 1966 and 1988 on this subject and concludes that orthodontic treatment can not be considered responsible for causing TMD. He found that from the 91 publications, 55 were viewpoint articles and were anecdotal, stating the opinion of the author regarding the orthodontic-TMJ dysfunction relationship. 30 articles were based on case reports, a category of publication that described the influence of certain orthodontic treatment modalities used in one or more patients on the signs and symptoms of TMJ dysfunction. 6 articles

were sample studies that reported data from big sample groups.[89] Reynders suggested that studies should be of the sample study variety with strict control of ethnic background, socioeconomic status, physiological status, age, sex of the patients, interobserver variability, type of appliance and placebo effects. All this factors are supposed to influence the prevalence and incidence of TMD.[33,89]

Sadowsky and BeGole found that in patients who underwent orthodontic treatment, the prevalence of TMJ dysfunction signs and symptoms was similar to that of the control group with untreated malocclusions. Furthermore, it was suggested that subjects who had undergone extensive fixed appliance orthodontic treatment many years previously, may possibly have a lower prevalence of TMJ problems than a similar group of adults with untreated malocclusions.[100] The sample in their study was of 75 adults, who had been treated with full orthodontic appliances as adolescents, compared to a group of 75 adults with untreated malocclusions. Following this study, Sadowsky, together with Polson, increased the sample used in Sadowsky's study and compared it with another treatment group, and concluded that there was no statistically significant difference between the orthodontically treated and untreated groups.[101] The results of both studies provide evidence that orthodontic treatment performed during adolescence generally does not increase or decrease the risk of developing temporomandibular joint dysfunction later in life.[100,101]

Larsson and Rönnerman, who also looked at the long-term effects of orthodontic treatment, affirmed that comprehensive orthodontic treatment can be undertaken without the risk of causing TMD.(29). They examined 23 adolescents, using the Helkimo index, who had been orthodontically treated 10 years before. They recorded mild dysfunction in eight patients, and severe dysfunction in only one patient.[102]

Kremenak et al., also state in their two studies, that orthodontic treatment is not an etiological factor for TMD.[103,104] In one of the studies, they examined 107 patients before orthodontic treatment and followed them for a mean period of two years. Only 10% of the patients had worsened TMD scores, while 90% of the patients had unchanged or even improved their TMD scores.[104] In their

other study, published the same year and in the same journal, they measured TMD scores in 65 patients. The patients had finished orthodontic treatment, and 39 of them were treated with premolar extractions (25 with four extractions and 14 with two upper premolars extractions). 26 of them were treated without extractions. The results did not show any statistically significant differences between mean pre-treatment and post-treatment scores. The results however, showed small statistically differences, in the improvement direction, between pre-treatment and post-treatment scores.[103]

Another study which defends the non- relationship between orthodontics and TMD, is the one done by Hirata et al. in 1992. They examined 102 patients before and after orthodontic treatment for TMD signs, and compared its findings to a group of 41 untreated individuals of the same age. Because they did not find any statistically differences between the groups, they concluded that orthodontic treatment did not increase nor decrease the TMD incidence.[105]

Rendell et al., in another study, examined 451 (90 % adolescents, 10% adults) patients who were receiving treatment in an orthodontic graduate clinic. Eleven of the patients had signs/symptoms of TMD prior to treatment. They studied the patients for 18 months and observed that none of the patients who had been free from signs/symptoms at the beginning of treatment developed signs or symptoms of TMD. In those patients with pre-existing signs/symptoms before the treatment beginning, there were no clear or consistent changes in the levels of pain and dysfunction. They concluded that no relationship could be established between orthodontic treatments in their sample.[106]

Dibbets and van der Weele published a 10-year longitudinal investigation of symptoms attributed to TMD in orthodontically treated individuals. Their hypothesis was that orthodontic therapy was an etiologic factor in inducing TMD. The prevalence of subjective symptoms, objective symptoms and x-ray findings were analyzed before treatment, 4 years later subsequent to retention and 10 years after the study initiation, and compared two different treatment modalities (Begg and Activator). They concluded that registration of symptoms during orthodontic treatment should be attributed to age changes, Begg Class I and Class II treatments do not reduce the percentages of symptoms registered

nor affect the incidence of subjective symptoms. These treatments do not affect the incidence of x-ray findings, and ten years after the beginning of treatment the initial differences in symptomatology between the two different treatment modalities no longer exist. However, they found that both treatment modalities created a higher percentage of objective symptoms after retention, but not in the long run (10 years).[96]

To the question if extractions could be a cause for TMD, we find another study also done by Dibbets and van der Weele 5 years later, in 1992, which supported that there was not a relationship between premolar extractions and TMD.[35] They examined 172 patients and followed them over 15 years. In their longitudinal study, 34 % of the patients had no extractions, 29% of the patients had four premolar extractions, and 37 % had other extraction patterns. The subjects were treated with either removable appliances or fixed appliances. In the first ten years, they did not find any differences between the groups regarding TMJ clicking. However, they found that after 15 years the clicking was more prevalent in the premolar extraction group. The authors affirmed, however, that this symptom was also higher in the group before any treatment was started, and concluded that the original growth pattern was the most likely factor responsible for TMD seen many years after treatment.[35]

O'Really and col., apart from analyzing the controversial effects of extractions, studied the effects of Class II elastics. Their sample consisted of 120 individuals: 60 orthodontically treated patients and 60 patients with no previous orthodontic treatment. They measured signs and symptoms of TMD dysfunction before, during and after treatment, and did not find any statistically significant differences between the groups. They concluded that neither extractions nor the use of Class II elastics had a big role to play in the presence of TMD.[107]

Whadhwa et al., in their study, compared the status of signs and symptoms from three different groups. 30 of the persons examined, had normal occlusion, 41 had untreated malocclusions and 31 had been orthodontically treated. Their results showed that the normal occlusion group had the maximum number of individuals free from any dysfunction, but this was not significant. Their only

significant finding was the difference in the clinical dysfunction index scores (Helkimo) of the persons with normal occlusions and untreated malocclusions. In conclusion they affirmed that the role of orthodontic treatment in either precipitation or prevention of TMD was still questionable.[36]

Imai et al. examined 58 patients retrospectively who had received splint therapy. The patients had had derangement of the TMJ. They divided the subjects into three groups. The first one was composed by 18 patients who underwent orthodontic treatment combined with the use of splints. The second group was composed by 27 patients who had been treated orthodontically but without any splint therapy. The last group was the one composed by 13 individuals who only had had a splint therapy. They analysed TMJ sound, pain on movement and restriction of mandibular movement at the initial examination, at the end of the splint therapy or beginning of the orthodontic treatment, at the end of the orthodontic treatment and at one year after the orthodontic treatment, with no significant differences between the groups. They did find a relationship between anterior open bite and TMD. Their results suggested that TMD symptoms that have been eliminated by split therapy are not likely to recur due to subsequent orthodontic treatment, but it could not be concluded that the orthodontic treatment itself had a positive effect on TMD.[108]

Egermark et al., in the year 2002, did not find any statistically significant differences in the prevalence of TMD signs and symptoms' between subjects with or without previous experience of orthodontic treatment. The investigation had 20 year period follow-up support and the sample was wide enough (402 patients from three different ages, followed 5 and 10 years after the first examination). They concluded that no single occlusal factor is of major importance for the development of TMD, but a lateral forced bite between retruded contact position and intercuspal position, as well as unilateral crossbite, may be a potential risk factor in this respect.[42] Three years later, Egermark et al. published a prospective long-term study of signs and symptoms of TMD in patients who had received orthodontic treatment in childhood and arrived to the same conclusion as in their other study: the orthodontic treatment in childhood does not entail an increased risk to develop either signs or symptoms of TMD later in life.[82]

Rey et al., made an evaluation of TMD in Class III patients treated with mandibular cervical headgear and fixed appliances. The examined 75 patients, 25 of them had no previous orthodontic treatment, 25 of them had undergone orthodontic treatment with fixed appliances and without extractions, and 25 of the patients had dentoskeletal Class III treated disharmonies. They did not find any greater prevalence of TMD in the Class III subjects than in the other two cases.[71]

In 2011, Kurt et al. evaluated two different therapy methods for Class III, both used in an early phase of Class III malocclusion and compared it with a non-treated Class III control group, and concluded that the use of Delaire facemask or the use of a Jasper Jumper did not result in TMD.[109]

Bales and Epstein also affirmed that orthodontic therapy may not affect the risk of developing TMD and has only little role as a treatment for TMD[31] what MCGuinness in a more recent study also supports.[110]

Riolo et al., Mohlin, Ingervall et al, Thilander et al., Egermark et al., Henrikson et al., are some of the authors which have suggested orthodontics as a treatment modality for the prevention of some TMD, since malocclusion has been by some implicated as a factor in the multifactorial etiology of TMD.[34,83,84,111-113]

Egermark and Thilander evaluated whether any differences could be found between individuals who had received orthondontic treatment earlier and those who had not. They used a wide sample of 402 children (7,11 and 15 years old) who had participated in a cross-sectional study, and examined them 10 years later. 190 subjects answered the questionnaire given 10 years after the previous examination, and 83 of them appeared for a clinical examination. They found that subjects with a history of orthodontic treatment had a lower prevalence of subjective symptoms o TMD than those who had not been treated. Although the differences they found were small, it was more evident for the oldest age group. The clinical examination showed that the orthodontically treated patients had a significant lower clinical dysfunction index than those who had not had any treatment.[34]

Henrikson, Nilner, and Kurol studied the relationship between orthondontics and TMD signs/symptoms in a prospective-longitudinal study in 65 adolescent girls with Class II malocclusion. They were examined before, during, after, and one year post treatment. Signs and symptoms showed considerable fluctuations over the three year period. The general tendency was a decreased prevalence of symptoms over the three years. The prevalence of pain on mandibular movement and masticatory muscles tenderness was significantly less common during and after orthodontic treatment than before. The clicking increased, but very slightly, over the three years. They concluded that the orthodontic treatment either with or without extractions did not increase the risk for TMD, and they found that individuals with Class II malocclusion and pre-treatment signs of TMD of muscular origin seemed even to benefit functionally from the treatment.[83] One year later, in 2000, the same authors published another prospective longitudinal study, but this time they added a non-treated Class II group as well as a control group with normal occlusion. They arrived to similar conclusions as in their previous study: orthodontic treatment did not increase the risk for TMD. On the contrary, subjects with class II malocclusions and signs of TMD of muscular origin seemed to improve functionally. The normal occlusion group had a lower prevalence of signs of TMD than the orthodontic and the untreated Class II group.[84] In 2003, Henrikson and Nilner published another article with additional records in the orthodontic group during active treatment and one year after it, and arrived to the same conclusions again. It is important to notice that they affirmed that TMD fluctuated individually over time with no predictable pattern, however they kept on insisting that the type of occlusion may play a role for TMD development.[65]

In a recent publication of the year 2012 Thilander and Bjerklin came to the conclusion, after their bibliography review on crossbites, TMDs and orthodontic treatment need, that a need for orthodontic treatment of a functional unilateral posterior crossbite shall focus mainly on the rehabilitation of the asymmetric muscular activity and the changed condylar position due to mandibular displacement (which was observed in many of the studies analyzed), but whether this should be a prophylactic measure in order to avoid TMDs can still not be answered.[114]

Al-Ryami et al., in their systematic review performed in 2009, analyzed the published data about orthognatic surgery (combined with orthodontics) and TMD and concluded that patients having orthognatic treatment for facial deformities who were suffering from TMD appeared more likely to have an improvement than deterioration with respect to TMD symptoms and signs.[115]

There are not many studies which report a negative relationship between othodontics and TMD, but if we named one it would be the one undertaken by Smith and Freer in 1989 published on the Australian Dental Journal (30). They examined 87 adolescent patients treated with orthodontic appliances comparing it to an untreated 28 adolescents control group. After examining them during their retention period, they found some symptoms in 21% of the treated group and they only found symptoms in 14 % of the untreated group. Nevertheless, they said there was no statically difference between the groups, but in the clicking, which almost occurred twice in the treated group. However they commented that it wasn't clinically significant.[116]

Although in Henrikson et al., studies they even saw a positive relationship between orthodontics and TMD, it is true that they also saw a slight increase of the clicking in treated subjects. However they did not find it significant, because the untreated group also showed an increase of the clicking through the years.[65,83,84]

Some have implicated orthodontics mechanotherapy to contribute to TMD. They have the theory that extractions and extensive tooth movements are the causes of posterior displacement of the condyles in the mandibular fossa, which results in anterior disc displacement.[90]

Wyatt insists on never performing any orthodontic procedure without considering its possible effects on the TMJ. In his article, published in 1987, he makes the following recommendations for diagnosis and treatment planning: mechanotherapy involving upward and backward pressures on the condyles should be avoided, final detailed correction of dental occlusion problems must always consider optimal temporomandibular health and function and retention procedures should be planned to prevent possible post treatment changes.[90]

In 1993 Artun et al., tested the hypothesis that retraction of maxillary front teeth might lock the mandible in a posterior position, and they evaluated if there was any relationship between condylar position and signs and symptoms of internal derangements in the TMJ. They examined a total of 29 female patients treated for Angle Class II division malocclusion with extractions of maxillary first premolars and 34 female patients treated for Angle Class I malocclusion without tooth extractions. All the patients were 16 years old and were examined twice, being the last time after 1,5 years. Condylar position was measured in anterior and posterior displacement on lateral, central and medial tomographic sections of each TMJ. They obtained a higher frequency of anteriorly positioned condyles in the non-extraction cases. No intergroup differences in sagittal occlusal slide from centric relation to maximal occlusion and no differences in the number of patients with clicking were found. However, they found that the condyles were located more posteriorly in all tomographic sections in patients with clicking than in those without.[117]

Roth[99] and some authors found in the Spanish literature, as Bujaldón[118,119], Sánchez Turrión[120], Jiménez-Castellanos[121] and Cebrián[122] consider an incorrect diagnosis and/or an incorrect orthodontic planning a risk factor for TMD. For all of them a perfect case finishing, with correct occlusal guides and optimal function was essential in order to prevent TMD.

In a more recent study, performed by Aidar et al. in 2010, they wanted to determine the changes in form and position of the articular disc in 32 patients receiving orthodontic treatment for Class II. After analysing magnetic resonances from every patient at different moments of the treatment, they concluded that in general terms, the position and form of the initial discs were maintained, but they observed however, some adverse effects in some of the temporomandibular joints after the fixed orthodontic phase.[123]

In the last years some authors have been searching for a genetic influence on TMD. It has been reported that a common variant of the gene that code for the enzyme catecol-O-methyltranferase (COMT) has been associated with a diminished activity of pain regulatory mechanisms in the central nervous system.[88] It seems probable that people with pain-sensitive haplotypes would

have experienced greater discomfort or pain when having a fixed orthodontic treatment. These findings could provide some biological plausibility to support an interpretation that orthodontic treatment could be a risk factor for TMD.[88] Slade et al., in their prospective cohort study, concluded that 'it would be premature to propose that orthodontia is a risk factor for TMD, even among the subgroup of females with pain-sensitive haplotyes of COMT'.[124] However, based on current evidence about biological processes involved in pain regulation, it seems possible that there could be a part of the population sensitive to noxious stimuli, and for those individuals who have experienced pain during orthodontic treatment, it may interact with that pain sensitivity.[124]

As we see, after an intense review of the literature up to our days, it's suggested that orthodontic treatment does not have nor has a minor role to play in worsening TMD, in studies which compare treated patients with untreated patients, with different types of orthodontic treatment, with or without different types of malocclusion. Its true that there is a tendency to show a reduction in TMD in orthodontically treated patients[34,35,40,83,84,96,97,100,111-113,115,125] but there's still debate regarding orthodontic treatment to improve TMD.

We found many studies that try to justify the absence of a relationship between orthodontic treatment and TMD. In these studies, TMD signs and symptoms are evaluated before, during and after orthodontic treatment, comparing them with a control group. In both groups signs and symptoms of TMD are found, and they conclude that these disorders are not influenced by the previous treatment.[31,33,35,36,65,71,82-86,97,98,100-107,109,110,117,125,127-129,131]

In the last place, we find a little group of studies that talk about a deleterious effect of orthodontic treatment on TMD. Some of them say that orthodontic treatment itself has a bad effect on these disorders, with no regard to the treatment done.[88,124] A bigger group says that orthodontics could be a potential TMD risk factor, if the patient is not well diagnosed. This means that orthodontic treatment would not be negative, if done correctly.[90,99,116-123]

From two of the last recent comprehensive meta-analysis found in the literature, [85,132] one published in 2002 and the other published in 2010, it can be concluded that traditional orthodontic treatment does not increase TMD risk, but

it is affirmed that a reliable and valid diagnostic classification system for TMD is needed for future research and that there is an urgent need for high quality randomised controlled trials in this area.

Although the concern about orthodontics as a possible etiological factor for TMD is lessening, as we see, debate is still open. Thus, this study will investigate the frequency and longitudinal evolution of signs and symptoms of temporomandibular joint disorders in subjects seeking orthodontic treatment, before and after being treated, in a selected German population.

4. Hypothesis

CHAPTER 4

HYPOTHESIS

1. Null Hypothesis: There is no significant difference in signs and symptoms of temporomandibular disorders nor in jaw eccentric movements in subjects before and after orthodontic treatment.
1. Alternative Hypothesis: There is significant difference in signs and symptoms of temporomandibular disorders and in jaw eccentric movements in subjects before and after orthodontic treatment.

2. Null Hypothesis: Most of the orthodontic treated patients maintain their previous status related to TMD and there are no changes in jaw eccentric movements after an orthodontic treatment.
2. Alternative Hypothesis: Most of the orthodontic treated patients improve/worsen their previous status related to TMD and there are some changes in jaw eccentric movements after an orthodontic treatment.

3. Null Hypothesis: There is no relation between patients' characteristics and subjective symptoms or objective signs of TMD.
3. Alternative Hypothesis: There is certain relation between patients' characteristics and subjective symptoms or objective signs of TMD.

4. Null Hypothesis: The different treatment modalities or the final treatment results do not influence the appearance of symptoms or signs of TMD after orthodontic treatment.
4. Alternative Hypothesis: The different treatment modalities or the final treatment results could influence the appearance of symptoms or signs of TMD after orthodontic treatment.

5. Materials and methods

CHAPTER 5

MATERIALS AND METHODS

5.1. Study design

This is a descriptive longitudinal study.

5.2. Subjects

The entire sample comprised of 95 patients with moderate to severe malocclusions seeking orthodontic treatment at the Orthodontic Office “Qualitätskieferorthopädie” in Isernhagen-Germany. According to the German KIG Malocclusion Classification (see Appendix 1) of five levels, only patients who were above the third level were included in the study.

From the total sample of 95 young patients included in this study, 49 were girls and 46 were boys.

Only residents of Low-Saxony in the age range of 5 to 19 years of age were included in the study.

Selection criteria were established to exclude other causes of TMJ dysfunction as much as possible (no individuals with a history of head or neck traumas, no individuals with any syndromes or diseases which could affect the TMJs).

The initial selection of the sample was based on the following criteria: good general health, good periodontal health and absence of carious lesions.

The whole sample, had moderate to severe untreated malocclusions before the orthodontic treatment and where examined before and after their treatment, once they received their definitive retention appliance.

When a person fulfilled these requirements, symptoms and signs of TMD were further evaluated before and after orthodontic treatment.

First of all, the frequency of subjective signs and objective symptoms was registered, followed by a study of the evolution of each patient, to finish then, with a correlation study according to different patient characteristics or patients' treatment characteristics for the whole sample:

❖ Groups according to patients' characteristics previous to treatment:

- Patients' gender (divided into two different groups): 49 girls and 46 boys.
- Age of treatment beginning (divided into four different groups): 8 years or younger (15 subjects), from 8 to 10 years (24 subjects), from 10 to 12 years (29 subjects) and older than 12 years (27 subjects).
- Skeletal Class at the beginning of the treatment (divided into three different groups): I (50 subjects), II (37 subjects) or III (8 subjects).
- Growth direction (divided into three different groups): neutral growth direction (34 subjects), vertical growth direction (20 subjects) or horizontal growth direction (41 subjects).
- Dental Class at the beginning of the treatment (divided into three different groups): I (14right-15left subjects), II (75right-72left subjects) or III (6 right-8left subjects).
- Crossbite at the beginning of the treatment (divided into two different groups): patients with crossbite (23 subjects) or patients without crossbite (72 subjects).
- Buccalbite at the beginning of the treatment (divided into two different groups): patients with buccalbite (5 subjects) or patients without buccalbite (90 subjects).
- Overjet at the beginning of the treatment (divided into two different groups): patients with an overjet of less than 6 mm. (74 subjects) or patients with an overjet above 6 mm. (20 subjects).

- Overbite at the beginning of the treatment (divided into two different groups): patients with an overbite of less than -2 mm. (2 subjects) or patients with an overbite of more than -2 mm. (92 subjects).

The orthodontic treatment goal was to normalize the sagittal, vertical and transversal dental relationships, and to eliminate crowding or spacing, giving the patient a correct lateral and protrusion functional guide eliminating important centric relation-maximal intercuspidation differences. This was achieved in most of the treated subjects. However, there was a group of 22 subjects where the objectives were not achieved and the reason was indicated (lack of mouth hygiene, non-compliance with elastics or hours of appliance-use, and/or treatment difficulties).

According to kind of treatment 14 subjects were treated with removal appliances, 37 subjects were treated with removal appliances and fixed appliances and 44 subjects were treated with fixed appliances.

From the total sample, 22 subjects were treated with extractions and 73 subjects were treated without extractions.

The mean active treatment period was of approximately 3 years.

❖ Groups according to treatment characteristics:

- Duration of treatment (divided into three different groups): 2 years or less than 2 (27 subjects), from 2 to 4 (43 subjects) and over 4 years (25 subjects).

- Kind of treatment (divided into three different groups): patients only treated with removal appliances (14 subjects), patients treated with fixed appliances (44 subjects) and patients treated with a combination of the last two (37 subjects).

- Extractions (divided into two different groups): patients treated with extractions (22 subjects) and patients treated without extractions (73 subjects).

- Ideal orthodontic objectives achieved (divided into two different groups): patients in whom the orthodontic objectives were achieved (73 subjects) and patients in whom the orthodontic objectives were not achieved (22 subjects).

5.3 Clinical examination and registration

Before the clinical registrations, the researcher (the author) was trained by specialists in the fields of orthodontics to be able to perform a comprehensive orthodontic evaluation (3 years Orthodontics Master's Degree) and was required to take part in a course of Manual Functional Diagnosis. In regard to the Manual Functional Analysis[6,133], the examiners were trained to locate the specific joint palpation sites, to apply a moderate pressure at these sites, to be able to slightly force the condyle to different positions and to locate the specific muscle.

The signs and symptoms were registered at each examination by either one of two specialists in orthodontics working at the Office, previously trained in Manual Functional Analysis. To calibrate the examination technique between the two specialists regarding the Routine Examination Protocol five subjects were examined by both examiners before and during the study. The calibration of the two examiners, showed a uniformity of 95 percent of registered signs.

Anamnestic and clinical registrations were made at the start and at the end of the active treatment in all of the patients. (Appendixes 2,3).

Registration of subjective symptoms was accomplished by the use of a questionnaire, interviewing the parents and the children. The questionnaire gathered demographic information, clinical record of diseases, allergies or trauma as well as answers to five questions related to subjective symptoms of TMJ:

- Do you have headaches or neck aches more than twice a week?

- Do you hear any clicking, popping, or grating noises from the joint, or do you feel pain when opening your mouth wide? Do you have to move your jaw sideways in order to open your mouth wide or to close it?
- Do your jaw muscles ache, feel tender or stiff after eating or awakening in the morning?
- Do you ever have pain in your ears, in front of your ears, or hear any noises?
- Do you feel dizzy often?

Also recorded on the same form were the types of treatment performed (removal appliances, fixed appliances, combination of the last two, or fixed appliances plus surgery treatment), whether extractions were made or not, treatment duration, and certain occlusal characteristics which included: Angle's dental classification before treatment, overjet and overbite before treatment, crossbite and buccalbite before treatment, skeletal class, growth direction, and if the perfect final occlusion after the treatment was achieved (and if not, the reason was also registered) (See Appendix 3).

The clinical signs registrations were performed according to the "Routine Protocol-Manual Functional Analysis" by Axel Bumann[6,133] (See Appendix 4).

Manual functional analysis according to Bumann and Lotzmann was used for individual examination of the structures within the TMJ and masticatory muscles. It consists of two parts: unspecific examination and specific examination. Unspecific examination comprises examination of active and passive mandibular movements and isometric strain of the masticatory muscles. It enables basic distinction of the causes of the disorders experienced by patients, that is, it determines whether the cause is of arthrogenous, myogenous or neurogenous origin. Specific examination comprises several techniques that include passive compressions, tractions, translations, dynamic compressions and translations, and joint and muscle palpation. Passive compressions, tractions and translations are commonly called TMJ examination techniques. They examine TMJ movements, the so-called joint play. These techniques are used for distinction of the changes in the area of joint surfaces,

joint ligaments, joint capsule and the bilaminar zone. Diagnosis of functional disorders of individual masticatory muscles is made by palpation, whereas functional disorders of the joint are diagnosed by means of dynamic compressions and translations. The moment, intensity and quality of clicking in the pathway of the condyles are observed after each compression and translation, and compared with the results of active movements without manipulation. The occurrence of pain and crepitation is also recorded. Clicking, crepitation and pain are clinical signs of specific significance for clinical diagnosis of TMD. Clicking is considered to be a sign of disk displacement, crepitation is considered as a sign of osteoarthrosis, and pain in the area of masticatory muscles or the TMJ as a sign of an acute inflammatory process.

- Mandibular mobility: The maximal opening, if less than 40mm, was considered limited, as well as the maximal laterotrusion and protrusion, if less than 7mm.[19]

- Retrusion of the lower jaw: the normal values we considered, were situated between 0,25-2,25 mm.[19]

- Endfeel distance: the normal values we considered were situated between 1-5 mm.[6]

- Deflection: by palpation, the condyles translation positions were examined in both maximal opening and maximal protrusion position and the differences between the left and right side were recorded (hipo-, normal, or hypermobility) and so, the subsequent deflection.[6]

- Pain if some during the passive jaw opening was recorded.[6]

- Whether the endfeel sensation was “too soft”, “to hard”, “elastic” or “bony” was recorded.[6]

- Dynamic compression (joint surfaces) during protrusive and opening movement: any rubbing sensations or pain were recorded.[6]

- Dynamic compression: any clicking during protrusive or opening movement, and the exact moment of the clicking (initial, intermediate or final) were

recorded for right and left sides without the use of a stethoscope as palpable or audible.[6]

- Dynamic translation: this variable was excluded because its difficult reproducibility intraobserver and the uncomfortable feeling for the children.[6]

- Passive compressions of the bilaminar zone: various joint structures were loaded in different directions. Pain if some, was recorded.[6] If the structures had an adaptation, a compensation or a decompensation, it was marked.

- Translation and caudal traction of the capsule and ligaments: pain if some, was recorded during anterolateral translation and inferior traction of the condyles.[6] It was registered if the structures had an adaptation, a compensation or a decompensation.

- Isometric contraction of the masticatory muscles: pain if some, during isometric 40 second contraction, was recorded within the depressor and elevator muscles.[6]

- Length of the suprahyoid structures: vertical or saggital shortness of the suprahyoid structures was registered if some.[6]

5.4. Data analysis

Data was entered into a computer using Software Stata which is a statistical package designed for the analysis of social science data.

The frequency of TMD symptoms and signs was analized for the entire sample and also for different groups. Comparisons between the results obtained before the orthodontic treatment and after it were also made, further analyzing whether the patients increased, decreased or maintained their TMD symptoms or signs if some, after the treatment.

The Spearman correlation was applied to the data for statistically significant differences before and after the treatment for the different groups.The Spearman's rank correlation coefficient r_s is computed by using rank scores R_i for X_i and C_i for Y_j. These rank scores are defined as follows:

$$R_i = \sum_{k<i} r_k + \frac{r_i + 1}{2}$$

$$C_j = \sum_{h<j} c_h + \frac{c_j + 1}{2}$$

For i = 1, 2 , ... , *R,* and for *j* = 1 , 2 , ... , *C.*

Furthermore, differences within the groups between the first and second measurement were calculated as follows: for binary variables McNemar's test was used and for normal distributed variables t-Student test was used.

The differences between the groups were calculated as follows: for binary variables the Pearson's chi-square test was used and for ordinal data the Mann-Whitney rank sum test was used.

P-values below 0,05 were considered as statistically significant.

Before starting the study, comparisons between the registrations of signs and symptoms between two clinicians (the main researcher and Dr. W.) were made. Five patients were selected and measured twice, indistinctly, by both observers. The objective was to measure the degree of agreement between two observers on the classification of an item between categories. In the case of dichotomous variables (Y / N) Cohen 's Kappa coefficient has been used , whilst for continuous variables, the intraclass correlation coefficient has been applied . Both coefficients measure interrater reliability taking into account the agreement occurring by chance. For both coefficients, 0 represents a degree of total disagreement, and 1 reflects full agreement. Data indicate that for dichotomous variables, the kappa coefficient is of 1 to at a 95 % level of confidence in all cases where it can be calculated , which corroborates an entire agreement between observers. In some cases it can not be calculated, since one or two observers only include one of the categories in their registrations. No other statistical index has been calculated. However, for the variables in which the kappa coefficient can not be calculated, the only case of disagreement between observers appeared for the variable " Opening / Protrusion deflection - After" for one of the patients, which indicates an almost total agreement between the two

observers. In the case of continuous variables , the intraclass correlation coefficient indicates the degree of agreement is also very high (almost total) , since in all cases the coefficient is 1 at a confidence level of 95% , except for the variable " maximal laterotrusion to the left - Before " , which is 0,999 and the variable" maximal laterotrusion to the right - Before " which is 0.996.

- *Pilot study*: a pilot study was carried out with 30 patients and it was found that the methodology of the present study was worth pursuing with a greater number of patients.

5.5. Ethical considerations

In Germany, Functional Manual Analysis Bumann is performed as part of the routine orthodontic diagnosis. This examination is non invasive and does not ever infringe patients' rights. In German Orthodontic Offices these registrations are taken as a complimentary diagnosis, together with other basic radiographic and clinical examinations, which are also necessary before starting any orthodontic treatment. For that reason it was not necessary to get any special permission from the Ethics Committee from Hannover Medical University.

It was mandatory, however, to inform the patients about our study and written Consent had to be signed from the patients' parents, so that no privacy rights could be infringed. (Appendix 5). All information obtained was treated with utmost confidentiality with only the author having access to personal information.

6. Results

CHAPTER 6

RESULTS

The results, as they are very extensive, have been organized as follows: first of all, a sample overview has been done, followed by subjective symtoms, eccentric movements and objective signs valuation. Both, subjective symptoms and objective signs, were further divided into four parts: TMD frequency evaluation, TMD evolution-longitudinal comparison, relation between patients characteristics and TMD, and relation between kind of treatment performed and final treatment results and TMD.

6.1. Participant Characteristics–Sample Overview

Ninety-five children and adolescents participated in the study being orthodontically treated. There were 49 female and 46 male subjects, between the ages of 5 and 19 years with a mean age of 11.02 years (Table 1). The male-female ratio was approximately 1:1. The mean duration of the treatment was of 3,16 years (Table 1).

Table 1: Patients´characteristics. Descriptive Statistics

	Min. Value	Max. Value	Mean	Standard deviation
Age start treatment (years)	5	19	11.02	2.52
Duration (years)	0.69	7.29	3.16	1.60

Notes: Sample: n=95; Min:minimal; Max:maximal

Table 1: Patients' characteristics. Descriptive Statistics

A 14,3 percent of the patients were treated with removal appliances (FA= functional appliances), 46,3 percent of the patients were treated with fixed appliances (MB= multibrackets) and 38,9 percent of all patients had a combination of both, removal and fixed appliances (FAMB= functional appliances plus multibrakets).

Table 2 shows the patients' characteristics distribution in percentages before starting the treatment, according to gender, age they were when the treatment was started, skeletal class, dental class, if the had a crossbite/buccalbite or not before the treatment beginning and overbite and overjet measurements before the treatment started. This crosstabulation (or double-entry table) also indicates the kind of treatment done in each patient (FAMB,MB,FA), whether extractions were made or not during the treatment, the treatment duration and if after the treatment the ideal orthodontic objectives were achieved. Fig. 2 illustrates the percentage over the full sample according to various patient characteristics.

Table 2: Crosstabulation: Patients' characteristics. Percentages

		Treatment			Extractions		Objectives achieved?		Total
		FAMB	FA	MB	Yes	No	Yes	No	
Gender	Female	21.1	7.4	23.2	10.5	41.1	42.1	9.5	51.6
	Male	17.9	7.4	23.2	12.6	35.8	34.7	13.7	48.4
Age start treat. (years)	≤8	5.3	10.5	0.0	1.1	14.7	11.6	4.2	15.8
	(8-10]	15.8	2.1	7.4	4.2	21.1	20.0	5.3	25.3
	(10-12]	13.7	1.1	15.8	5.3	25.3	24.2	6.3	30.5
	>12	4.2	1.1	23.2	12.6	15.8	21.1	7.4	28.4
Duration treat. (years)	≤2	2.1	12.6	13.7	4.2	24.2	24.2	4.2	28.4
	(2-4]	20.0	1.1	24.2	13.7	31.6	32.6	12.6	45.3
	>4	16.8	1.1	8.4	5.3	21.1	20.0	6.3	26.3
Skeletal class	I	16.8	7.4	28.4	10.5	42.1	45.3	7.4	52.6
	II	20.0	4.2	14.7	11.6	27.4	25.3	13.7	38.9
	III	2.1	3.2	3.2	1.1	7.4	6.3	2.1	8.4
Dental class right	I	4.2	4.2	6.3	1.1	13.7	11.6	3.2	14.7
	II	32.6	8.4	37.9	22.1	56.8	61.1	17.9	78.9
	III	2.1	2.1	2.1	0.0	6.3	4.2	2.1	6.3
Dental class left	I	5.3	3.2	7.4	2.1	13.7	12.6	3.2	15.8
	II	31.6	7.4	36.8	21.1	54.7	58.9	16.8	75.8
	III	2.1	4.2	2.1	0.0	8.4	5.3	3.2	8.4
Crossbite	Yes	4.2	10.5	9.5	1.1	23.2	20.0	4.2	24.2
	No	34.7	4.2	36.8	22.1	53.7	56.8	18.9	75.8
Buccalbite	Yes	2.1	0.0	3.2	0.0	5.3	4.2	1.1	5.3
	No	36.8	14.7	43.2	23.2	71.6	72.6	22.1	94.7
Overjet (mm.)	≤6	25.3	14.7	37.9	16.8	61.1	60.0	17.9	77.9
	>6	12.6	0.0	8.4	5.3	15.8	15.8	5.3	21.1
Overbite (mm.)	≤-2	0.0	1.1	1.1	1.1	1.1	1.1	1.1	2.1
	>-2	37.9	13.7	45.3	21.1	75.8	74.7	22.1	96.8
Total		38.9	14.7	46.3	23.2	76.8	76.8	23.2	100.0

Notes: FAMB(Functional appliances combined with multibrackets); FA(Functional appliances); MB(Multibrackets)

Table 2: Crosstabulation: Patients' characteristics. Percentages.

Figure 2: Patients´characteristics

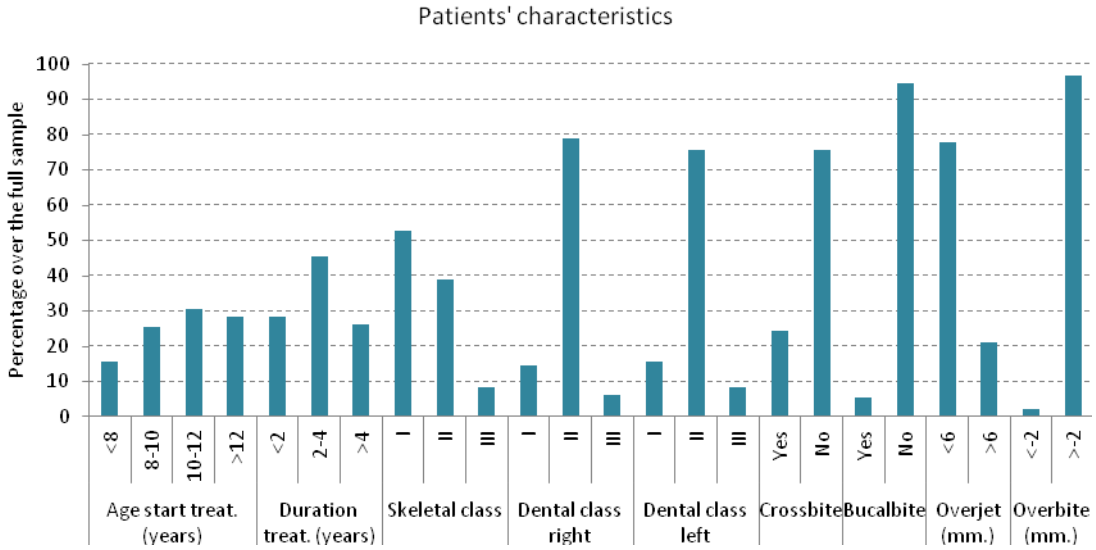


Figure 2: Patients characteristics' distribution

6.2. Subjective symptoms of TMD

6.2.1. Frequency of subjective symptoms of TMD

The results of the patients recorded with or without subjective symptoms are captured in Table 3.

Every patient was evaluated before and after orthodontic treatment. At the same time, this crosstabulation illustrates the distribution of the symptoms before/after treatment according to various patients' characteristics.

Fig. 3 graphically illustrates the frequency of subjective occurrence of headpain, temporomandibular joint pain, muscle tenderness, ear sounds and dizziness recorded in the patients/parents interviews before an after the orthodontic treatment.

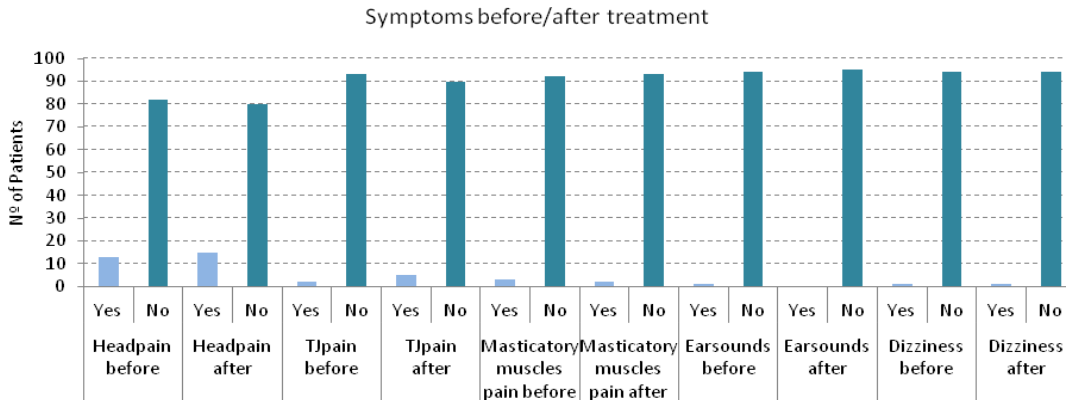
Table 3: Symptoms before/after treatment according to patient's characteristics. Nº of patients

		Headpain before		Headpain after		TJpain before		TJpain after		Masticatory muscles pain before		Masticatory muscles pain after		Earsounds before		Earsounds after		Dizziness before		Dizziness after	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Gender	Female	6	43	8	41	1	48	3	46	1	48	1	48	1	48	0	49	1	48	1	48
	Male	7	39	7	39	1	45	2	44	2	44	1	45	0	46	0	46	0	46	0	46
Treatment	FAMB	2	35	3	34	0	37	4	33	1	36	1	36	1	36	0	37	0	37	0	37
	FA	2	12	2	12	0	14	0	14	1	13	1	13	0	14	0	14	0	14	0	14
	MB	9	35	10	34	2	42	1	43	1	43	0	44	0	44	0	44	1	43	1	43
Duration (years)	≤2	3	24	3	24	1	26	0	27	1	26	0	27	0	27	0	27	0	27	0	27
	(2-4]	7	36	10	33	1	42	5	38	1	42	2	41	0	43	0	43	0	43	0	43
	>4	3	22	2	23	0	25	0	25	1	24	0	25	1	24	0	25	1	24	1	24
Extractions	Yes	6	16	7	15	0	22	2	20	1	21	2	20	0	22	0	22	1	21	1	21
	No	7	66	8	65	2	71	3	70	2	71	0	73	1	72	0	73	0	73	0	73
Retrusion before (m.t.a.)	Yes	1	1	1	1	0	2	1	1	0	2	0	2	0	2	0	2	0	2	0	2
	No	12	81	14	79	2	91	4	89	3	90	2	91	1	92	0	93	1	92	1	92
Crossbite	Yes	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23	0	23
	No	13	59	15	57	2	70	5	67	3	69	2	70	1	71	0	72	1	71	1	71
Overjet (mm.)	≤6	11	63	11	63	2	72	3	71	3	71	2	72	1	73	0	74	0	74	0	74
	>6	2	18	4	16	0	20	2	18	0	20	0	20	0	20	0	20	1	19	1	19
Overbite (mm.)	≤-2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2
	>-2	13	79	15	77	2	90	5	87	3	89	2	90	1	91	0	92	1	91	1	91
Dental class right	I	0	14	1	13	0	14	1	13	0	14	0	14	0	14	0	14	0	14	0	14
	II	13	62	14	61	2	73	4	71	3	72	2	73	1	74	0	75	1	74	1	74
	III	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6	0	6
Dental class left	I	2	13	3	12	0	15	1	14	0	15	0	15	0	15	0	15	0	15	0	15
	II	11	61	12	60	2	70	4	68	3	69	2	70	1	71	0	72	1	71	1	71
	III	0	8	0	8	0	8	0	8	0	8	0	8	0	8	0	8	0	8	0	8
Skeletal class	I	7	43	8	42	0	50	3	47	0	50	0	50	0	50	0	50	0	50	0	50
	II	6	31	7	30	2	35	2	35	3	34	2	35	1	36	0	37	1	36	1	36
	III	0	8	0	8	0	8	0	8	0	8	0	8	0	8	0	8	0	8	0	8
Objectives achieved?	Yes	10	63	12	61	2	71	2	71	2	71	1	72	1	72	0	73	1	72	1	72
	No	3	19	3	19	0	22	3	19	1	21	1	21	0	22	0	22	0	22	0	22
TOTAL		13	82	15	80	2	93	5	90	3	92	2	93	1	94	0	95	1	94	1	94

Notes: Sample: n=95 except for overbite and overjet: n=94; m.t.a.: more than average; FAMB(Functional appliances combined with multibrackets); FA(Functional appliances); MB(Multibrackets); TJ: temporomandibular joint

Table 3: Symptoms before/after treatment according to patient's characteristics. Nº of patients.

Figure 3: Symptoms before/after treatment according to patient's characteristics. Nº of patients

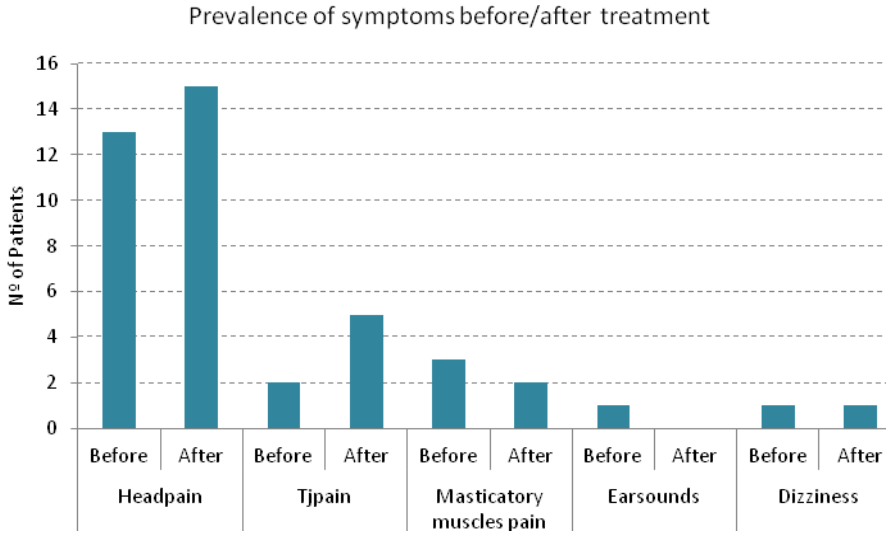


Notes: TJ: temporomandibular joint

Figure 3: Symptoms before/after treatment according to patient's characteristics. Nº of patients.

In order to summarize Table 3, just patients with recorded symptoms have been reflected in Table 4 and 5, with their related graphics (Fig.4 and Fig.5). Table 4 and Fig. 4 indicate the number of patients with subjective symptoms and Table 5 and Fig. 5 indicate the same but in percentages.

Figure 4: Prevalence of symptoms before/after treatment according to patient's characteristics. Nº of patients



Notes: TJ: temporomandibular joint

Figure 4: Prevalence of symptoms before/after treatment according to patient's characteristics. Nº of patients.

Table 4: Prevalence of symptoms before/after treatment according to patient's characteristics. Nº of patients

		Head pain		TJ pain		Masticatory muscles pain		Ear sounds		Dizziness	
		Before	After	Before	After	Before	After	Before	After	Before	After
Gender	Female	6	8	1	3	1	1	1	0	1	1
	Male	7	7	1	2	2	1	0	0	0	0
Treatment	FAMB	2	3	0	4	1	1	1	0	0	0
	FA	2	2	0	0	1	1	0	0	0	0
	MB	9	10	2	1	1	0	0	0	1	1
Duration (years)	≤2	3	3	1	0	1	0	0	0	0	0
	(2-4]	7	10	1	5	1	2	0	0	0	0
	>4	3	2	0	0	1	0	1	0	1	1
Extractions	Yes	6	7	0	2	1	2	0	0	1	1
	No	7	8	2	3	2	0	1	0	0	0
Retrusion before (m.t.a.)	Yes	1	1	0	1	0	0	0	0	0	0
	No	12	14	2	4	3	2	1	0	1	1
Crossbite	Yes	0	0	0	0	0	0	0	0	0	0
	No	13	15	2	5	3	2	1	0	1	1
Overjet (mm.)	≤6	11	11	2	3	3	2	1	0	0	0
	>6	2	4	0	2	0	0	0	0	1	1
Overbite (mm.)	≤-2	0	0	0	0	0	0	0	0	0	0
	>-2	13	15	2	5	3	2	1	0	1	1
Dental class right	I	0	1	0	1	0	0	0	0	0	0
	II	13	14	2	4	3	2	1	0	1	1
	III	0	0	0	0	0	0	0	0	0	0
Dental class left	I	2	3	0	1	0	0	0	0	0	0
	II	11	12	2	4	3	2	1	0	1	1
	III	0	0	0	0	0	0	0	0	0	0
Skeletal class	I	7	8	0	3	0	0	0	0	0	0
	II	6	7	2	2	3	2	1	0	1	1
	III	0	0	0	0	0	0	0	0	0	0
Objectives achieved?	Yes	10	12	2	2	2	1	1	0	1	1
	No	3	3	0	3	1	1	0	0	0	0
Total		13	15	2	5	3	2	1	0	1	1

Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; FAMB(Functional appliances combined with multibrackets); FA(Functional appliances); MB(Multibrackets)

Table 4: Prevalence of symptoms before/after treatment according to patient's characteristics. Nº of patients.

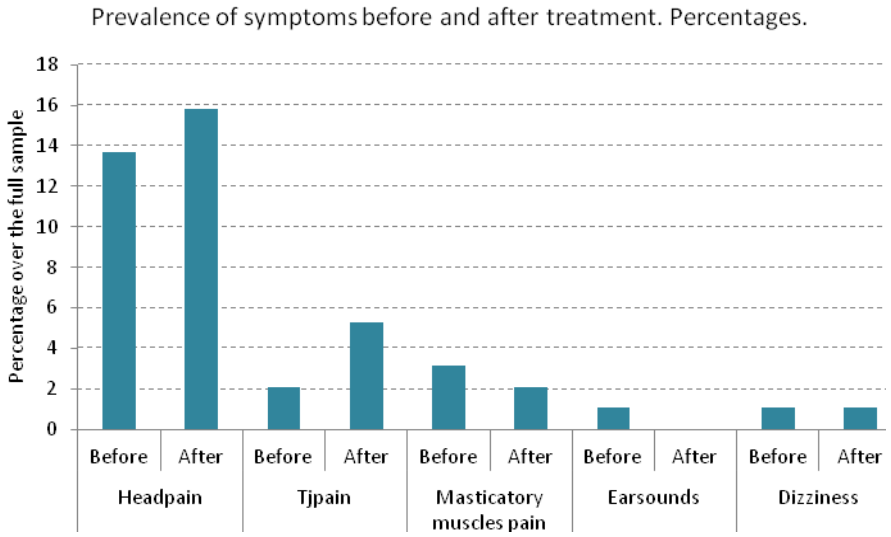
Table 5: Prevalence of symptoms before/after treatment according to patient's characteristics. Percentages

		Head pain		TJ pain		Masticatory muscles pain		Ear sounds		Dizziness	
		Before	After	Before	After	Before	After	Before	After	Before	After
Gender	Female	6.3	8.4	1.1	3.2	1.1	1.1	1.1	0.0	1.1	1.1
	Male	7.4	7.4	1.1	2.1	2.1	1.1	0.0	0.0	0.0	0.0
Treatment	FAMB	2.1	3.2	0.0	4.2	1.1	1.1	1.1	0.0	0.0	0.0
	FA	2.1	2.1	0.0	0.0	1.1	1.1	0.0	0.0	0.0	0.0
	MB	9.5	10.5	2.1	1.1	1.1	0.0	0.0	0.0	1.1	1.1
Duration (years)	≤2	3.2	3.2	1.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0
	(2-4]	7.4	10.5	1.1	5.3	1.1	2.1	0.0	0.0	0.0	0.0
	>4	3.2	2.1	0.0	0.0	1.1	0.0	1.1	0.0	1.1	1.1
Extractions	Yes	6.3	7.4	0.0	2.1	1.1	2.1	0.0	0.0	1.1	1.1
	No	7.4	8.4	2.1	3.2	2.1	0.0	1.1	0.0	0.0	0.0
Retrusion before (m.t.a.)	Yes	1.1	1.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
	No	12.6	14.7	2.1	4.2	3.2	2.1	1.1	0.0	1.1	1.1
Crossbite	Yes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	No	13.7	15.8	2.1	5.3	3.2	2.1	1.1	0.0	1.1	1.1
Overjet (mm.)	≤6	11.7	11.7	2.1	3.2	3.2	2.1	1.1	0.0	0.0	0.0
	>6	2.1	4.3	0.0	2.1	0.0	0.0	0.0	0.0	1.1	1.1
Overbite (mm.)	≤-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	>-2	13.8	16.0	2.1	5.3	3.2	2.1	1.1	0.0	1.1	1.1
Dental class right	I	0.0	1.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
	II	13.7	14.7	2.1	4.2	3.2	2.1	1.1	0.0	1.1	1.1
	III	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dental class left	I	2.1	3.2	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
	II	11.6	12.6	2.1	4.2	3.2	2.1	1.1	0.0	1.1	1.1
	III	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Skeletal class	I	7.4	8.4	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.0
	II	6.3	7.4	2.1	2.1	3.2	2.1	1.1	0.0	1.1	1.1
	III	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Objectives achieved?	Yes	10.5	12.6	2.1	2.1	2.1	1.1	1.1	0.0	1.1	1.1
	No	3.2	3.2	0.0	3.2	1.1	1.1	0.0	0.0	0.0	0.0
Total		13.7	15.8	2.1	5.3	3.2	2.1	1.1	0.0	1.1	1.1

Notes: Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; FAMB(Functional appliances combined with multibrackets); FA(Functional appliances); MB(Multibrackets); TJ: temporomandibular joint.

Table 5: Prevalence of symptoms before/after treatment according to patient's characteristics. Percentages.

Figure 5: Prevalence of symptoms before/after treatment according to patient's characteristics. Percentages



TJ: temporomandibular joint

Figure 5: Prevalence of symptoms before/after treatment according to patient's characteristics. Percentages.

Amongst the symptoms, the most frequently recorded was head pain, followed by temporomandibular joint pain and muscle tenderness. Ear sounds and dizziness were the least reported symptoms. There were no subjects with severe subjective symptoms.

The differences between the percentage of patients which had the symptoms before and after orthodontic treatment are recorded in Table 6 and Fig. 6.

Fig. 6 graphically illustrates that the percentage of patients with head pain and and temporomandibular pain increased after the treatment, while the percentage of patients who reported muscle tenderness and ear sounds decreased after the orthodontic treatment. The differences are though minimal.

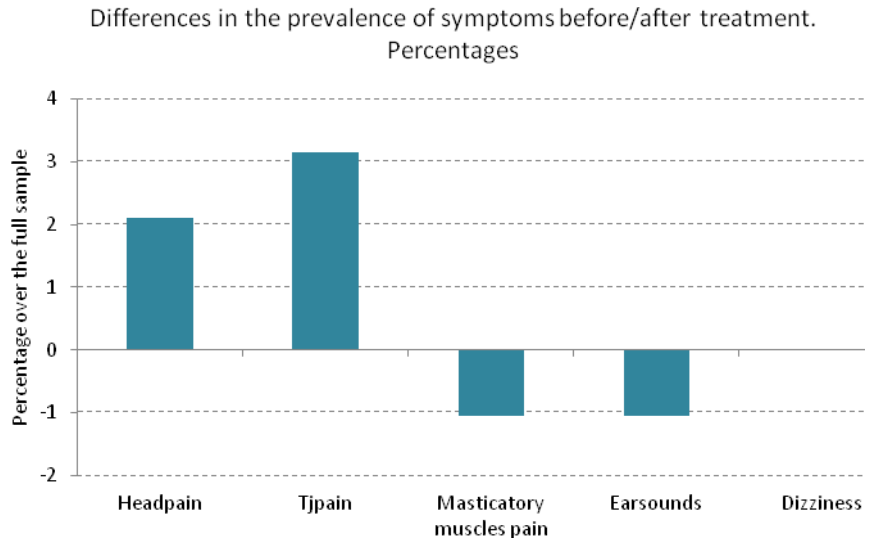
Table 6: Differences in prevalence of symptoms. Percentages

		Headpain	Tjpain	Masticatory muscles pain	Earsounds	Dizziness
Gender	Female	2.11	2.11	0.00	-1.05	0.00
	Male	0.00	1.05	-1.05	0.00	0.00
Treatment	FAMB	1.05	4.21	0.00	-1.05	0.00
	FA	0.00	0.00	0.00	0.00	0.00
	MB	1.05	-1.05	-1.05	0.00	0.00
Duration (years)	≤2	0.00	-1.05	-1.05	0.00	0.00
	(2-4]	3.16	4.21	1.05	0.00	0.00
	>4	-1.05	0.00	-1.05	-1.05	0.00
Extractions	Yes	1.05	2.11	1.05	0.00	0.00
	No	1.05	1.05	-2.11	-1.05	0.00
Retrusion before (m.t.a.)	Yes	0.00	1.05	0.00	0.00	0.00
	No	2.11	2.11	-1.05	-1.05	0.00
Crossbite	Yes	0.00	0.00	0.00	0.00	0.00
	No	2.11	3.16	-1.05	-1.05	0.00
Overjet (mm.)	≤6	0.00	1.06	-1.06	-1.06	0.00
	>6	2.13	2.13	0.00	0.00	0.00
Overbite (mm.)	≤-2	0.00	0.00	0.00	0.00	0.00
	>-2	2.11	3.16	-1.05	-1.05	0.00
Dental class right	I	1.05	1.05	0.00	0.00	0.00
	II	1.05	2.11	-1.05	-1.05	0.00
	III	0.00	0.00	0.00	0.00	0.00
Dental class left	I	1.05	1.05	0.00	0.00	0.00
	II	1.05	2.11	-1.05	-1.05	0.00
	III	0.00	0.00	0.00	0.00	0.00
Skeletal class	I	1.05	3.16	0.00	0.00	0.00
	II	1.05	0.00	-1.05	-1.05	0.00
	III	0.00	0.00	0.00	0.00	0.00
Objectives achieved?	Yes	2.11	0.00	-1.05	-1.05	0.00
	No	0.00	3.16	0.00	0.00	0.00
Total		2.11	3.16	-1.05	-1.05	0.00

Notes: Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; FAMB(Functional appliances combined with multibrackets); FA(Functional appliances); MB(Multibrackets)

Table 6: Differences in prevalence of symptoms. Percentages.

Figure 6: Differences in prevalence of symptoms. Percentages



TJ: temporomandibular joint

Figure 6: Differences in prevalence of symptoms. Percentages.

6.2.2. EVOLUTION OF SUBJECTIVE SYMPTOMS OF TMD

In order to compare the patients who maintained or changed each subjective symptom (before-after treatment) Table 7 and Fig. 7a,7b have been designed.

Most of the patients reported no symptoms before nor after the treatment (a range going from 82,11 percent to 98,95 percent. These are described as “No-No” (No symptoms before treatment-No symptoms after treatment). 11,58 percent of the patients according to head pain and 1,05 percent according to muscle tenderness and dizziness, maintained their symptoms previous to treatment with no variation after treatment. These are described as “Yes-Yes” (With symptoms before treatment- With symptoms after treatment). 2,11 percent of the patients improved after the treatment according to head pain, temporomandibular joint pain and muscle tenderness and a 1,05 percent according to ear sounds. These are described as “Yes-No” (With symptoms before treatment- No symptoms after treatment). 5,26 percent worsened their previous situation according to temporomandibular joint pain, and 1,05 according to muscle tenderness. These are described as “No-Yes” (No symptoms before treatment-With symptoms after treatment).

Table 7: Evolution of symptoms before/after treatment. Percentages

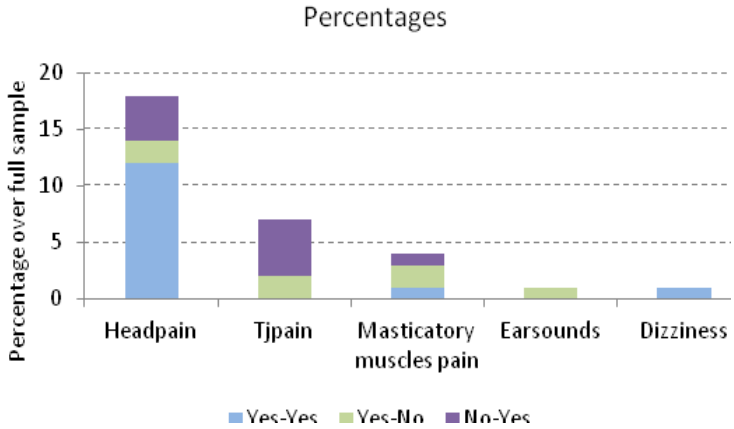
Before-After treatment	Headpain	Tjpain	Masticatory muscles pain	Earsounds	Dizziness
No-No	82.11	92.63	95.79	98.95	98.95
Yes-Yes	11.58	0.00	1.05	0.00	1.05
Yes-No	2.11	2.11	2.11	1.05	0.00
No-Yes	4.21	5.26	1.05	0.00	0.00
Total	100	100	100	100	100

Notes: Sample: n=95; TJ: temporomandibular joint

Table 7: Evolution of symptoms before/after treatment. Percentages

Fig. 7a illustrates only the patients who reported symptoms.

Figure 7a: Evolution of symptoms before/after treatment. Percentages

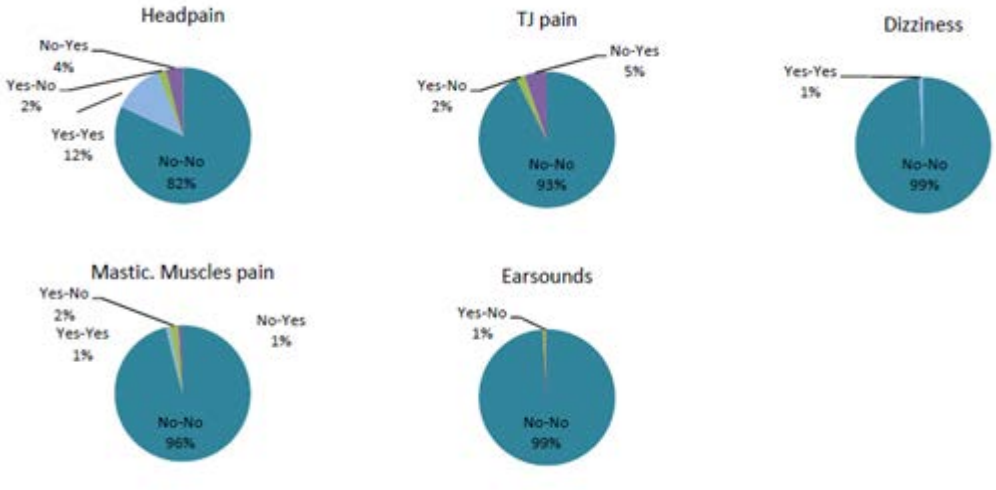


Notes: TJ: temporomandibular joint

Figure 7a: Evolution of symptoms before/after treatment. Percentages.

Fig. 7b clearly illustrates that most of the children and adolescent evaluated maintained their previous status according to their subjective symptoms, with very slightly variations after the orthodontic treatment.

Figure 7b: Evolution of symptoms before/after treatment. Percentages



Notes: TJ: temporomandibular joint; Mastic: masticatory

Figure 7b: Evolution of symptoms before/after treatment. Percentages.

6.2.3. Relation between patients' characteristics and kind of performed treatment and subjective symptoms of TMD

The relations between two variables (the different symptoms and the patients' characteristics before treatment or patients' treatment characteristics) and the direction and strength of such a relation are represented in Table 8.

Table 8: Spearman's rank correlation coefficient between Patients' characteristics and symptoms

	Headpain		TJ pain		Masti pain		Earsounds		Dizziness	
	Before	After	Before	After	Before	After	Before	After	Before	After
Gender										
Age start treat. (years)										
Duration treat. (years)										
Treatment	0.1973*	0.1813*		-0.1737*						
Extractions	0.2290**	0.2545**				0.2749***			0.1933*	0.1933*
Dental class right										
Dental class left										
Crossbite	-0.2280**	-0.2480**								
Bucalbite			0.2936***		0.2267**					
Overjet (mm.)										
Overbite (mm.)		0.1949*	0.2337**							
Skeletal class										
Objectives achieved?				-0.2049**						
Retrusion before (mm.)										

Notes: Asterisks denote significance level, with ****P<0.01*, ***P<0.05* and **P<0.1*.; Sample: n=95 except for overbite and overjet: n=94; TJ: temporomandibular joint; Masti: masticatory muscles

Table 8: Relation between Patients' characteristics and symptoms.

The results show no statistically significant differences between males and females, age of treatment start, duration of treatment, dental class, overjet and skeletal class, for subjective symptoms of TMD.

However, statistically significant differences were found according to the kind of treatment. Patients who had undergone fixed multiband appliances (MB) had a higher tendency to decrease the subjective TJ pain than patients who underwent removal appliances treatment (FA) or the combination of removal and fixed appliances after their orthodontic treatment (FAMB).

There were also statistically significant differences according to the patients who had had extractions, as they showed a tendency to report more muscle tenderness after the treatment.

Patients with a deeper overbite before the treatment reported more head pain after treatment.

It is important to notice that statistically significant differences were found in relation to treatment finishing: if the ideal orthodontic objectives were achieved, it implied a decrease of the TJ pain reported after the treatment.

It is also statistically significant that patients, who presented a buccalbite before the treatment, reported TJ pain and muscle tenderness before being treated and this significance disappeared after the treatment. The same occurs to patients with deeper bite: they had a tendency to report TJ pain before the treatment and its significance disappears after the treatment.

The relation between the variables of kind of treatment-head pain, extractions-head pain, crossbite-head pain and extractions-dizziness will not be considered relevant as they do not show important variations before or after treatment. From these relations we can though interpret that patients who had undergone fixed appliances had a higher tendency to have more head pain before and after the treatment than patients with removal appliances or combined treatment, that patients who had had extractions (which implies more crowding before the treatment) had a tendency to have head pain and dizziness before and after the treatment, and that patients with crossbite had less head pain before and after the treatment.

Using the Pearson's Chi-Square Test no statistically significant relationships were found. However, a dependency between TJ pain before and Overbite was found according to Mann-Whitney's test (patients with a deeper overbite, presented more TJ pain symptoms before treatment).

6.3. Jaw excentric movements before and after treatment

Table 9 illustrates the minimal and maximal values of excentric movements recorded before and after treatment. In relation to maximal mouth opening the values tend to increase after the treatment but the patients' values differ widely from each other with a standard deviation of nearly 5 mm. The same happens to maximal laterotrusion movements to both sides and to protrusive movement,

but in these cases the deviations are much smaller. Passive translation is the only measure which does not tend to increase after treatment.

Table 9: Descriptive Statistics

		Min. Value	Max. Value	Mean	Standard deviation
Max. opening (mm.)	Before	25	58	46.01	5.34
	After	39	64	48.58	5.14
Max. laterotrusion to the left (mm.)	Before	4	19	9.00	2.03
	After	6	15	9.30	1.83
Max. laterotrusion to the right (mm.)	Before	3	13	8.75	2.10
	After	5	15	9.38	1.75
Protrusion (mm.)	Before	4	19	8.92	2.57
	After	5	14	9.40	1.89
Pasive translation (mm.)	Before	2	6	2.94	0.84
	After	1	6	2.93	0.93

Notes: Sample: n=95 ; Max: maximal ; Min: minimal

Table 9: Value of excentric movements before and after orthodontic treatment.

6.4. Objective signs of TMD

6.4.1. Frequency of objective signs of TMD

The results of the number of patients with objective signs for TMD are captured in Tables 10a, 10b and 10c.

Every patient was evaluated before and after orthodontic treatment using Bumann's Routine Protocol and each sign if any, was recorded in the Tables. At the same time, this crosstabulation illustrates the distribution of the TMD signs before/after treatment according to various patients' characteristics.

Table 10a: Prevalence of signs before/after treatment according to patient's characteristics. Nº of patients (I)

		Max. Opening limitation		Max. laterotrusion limitation (left)		Max. laterotrusion limitation (right)		Protrusion limitation	
		Before	After	Before	After	Before	After	Before	After
Gender	Female	3	0	5	2	5	1	8	4
	Male	0	0	1	2	6	1	5	1
Treatment	FAMB	1	0	2	1	6	2	4	1
	FA	1	0	1	0	2	0	4	3
	MB	1	0	3	3	3	0	5	1
Duration (years)	≤2	1	0	2	1	2	0	4	2
	(2-4]	1	0	2	2	5	1	3	2
	>4	1	0	2	1	4	1	6	1
Extractions	Yes	0	0	3	1	3	0	5	1
	No	3	0	3	3	8	2	8	4
Retrusion before (m.t.a.)	Yes	0	0	0	0	0	0	0	0
	No	3	0	6	4	11	2	13	5
Crossbite	Yes	1	0	2	0	4	0	4	2
	No	2	0	4	4	7	2	9	3
Overjet (mm.)	≤6	3	0	5	2	9	2	11	5
	>6	0	0	1	2	2	0	1	0
Overbite (mm.)	≤-2	0	0	0	0	0	0	1	1
	>-2	3	0	6	4	11	2	11	4
Dental class right	I	0	0	0	0	2	1	2	1
	II	2	0	4	4	8	0	9	3
	III	1	0	2	0	1	1	2	1
Dental class left	I	0	0	0	0	2	1	3	1
	II	2	0	4	4	8	0	8	3
	III	1	0	2	0	1	1	2	1
Skeletal class	I	2	0	3	3	7	1	4	2
	II	0	0	1	1	2	0	5	1
	III	1	0	2	0	2	1	4	2
Growth direction	CCW	2	0	2	2	2	1	2	0
	CW	0	0	3	1	2	0	3	0
	NEU	1	0	1	1	7	1	8	5
Objectives achieved?	Yes	3	0	5	4	10	1	11	5
	No	0	0	1	0	1	1	2	0
Total		3	0	6	4	11	2	13	5

Notes: Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; Max.:maximal; FAMB(Functional appliances combined with multibrackets)/ FA(Functional appliances)/ MB(Multibrackets); CCW (Horizontal growth direction)/ CW (Vertical growth direction)/ NEU (Neutral growth direction)

Table 10a: Prevalence of signs before/after treatment according to patient's characteristics. Nº of patients (I).

Table 10b: Prevalence of signs before/after treatment according to patient's characteristics. Nº of patients (II)

		Deflexion of the mandible		Passive translation (out of average)		Pain during passive translation (right)		Pain during passive translation (left)		Endfeeling (different than average)	
		Before	After	Before	After	Before	After	Before	After	Before	After
Gender	Female	26	22	0	0	0	3	0	1	2	2
	Male	26	18	1	3	0	1	0	1	2	3
Treatment	FAMB	21	18	0	1	0	2	0	0	2	2
	FA	8	4	1	0	0	1	0	0	2	2
	MB	23	18	0	2	0	1	0	2	0	1
Duration (years)	≤2	14	7	1	1	0	1	0	0	1	1
	(2-4]	26	19	0	2	0	3	0	2	2	3
	>4	12	14	0	0	0	0	0	0	1	1
Extractions	Yes	10	8	0	1	0	2	0	1	1	1
	No	42	32	1	2	0	2	0	1	3	4
Retrusion before (m.t.a.)	Yes	1	0	0	0	0	1	0	0	0	0
	No	51	40	1	3	0	3	0	2	4	5
Crossbite	Yes	14	9	1	0	0	1	0	0	1	1
	No	38	31	0	3	0	3	0	2	3	4
Overjet (mm.)	≤6	45	33	1	2	0	4	0	1	3	4
	>6	7	7	0	1	0	0	0	1	1	1
Overbite (mm.)	≤-2	1	1	0	0	0	0	0	0	0	0
	>-2	51	39	1	3	0	4	0	2	4	5
Dental class right	I	7	5	0	0	0	1	0	0	0	0
	II	42	31	0	3	0	3	0	2	3	4
	III	3	4	1	0	0	0	0	0	1	1
Dental class left	I	8	5	0	0	0	1	0	0	0	0
	II	41	31	0	3	0	2	0	2	3	4
	III	3	4	1	0	0	1	0	0	1	1
Skeletal class	I	27	18	0	2	0	3	0	1	1	2
	II	20	16	0	1	0	1	0	1	2	2
	III	5	6	1	0	0	0	0	0	1	1
Growth direction	CCW	24	18	1	1	0	2	0	2	3	4
	CW	12	10	0	1	0	0	0	0	1	1
	NEU	16	12	0	1	0	2	0	0	0	0
Objectives achieved?	Yes	40	29	1	3	0	3	0	2	3	4
	No	12	11	0	0	0	1	0	0	1	1
Total		52	40	1	3	0	4	0	2	4	5

Notes: Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; FAMB(Functional appliances combined with multibrackets)/ FA(Functional appliances)/ MB(Multibrackets); CCW (Horizontal growth direction)/ CW (Vertical growth direction)/ NEU (Neutral growth direction)

Table 10b: Prevalence of signs before/after treatment according to patient's characteristics. Nº of patients (II).

Table 10c: Prevalence of signs before/after treatment according to patient's characteristics. Nº of patients (III)

		Clicking		Passive compressions (right)		Passive compressions (left)		Muscle tenderness		Traction and translations		Length of the suprahyoid structures	
		Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Gender	Female	1	6	1	7	2	4	17	9	1	1	0	0
	Male	2	2	7	9	4	1	18	7	0	3	0	0
Treatment	FAMB	1	5	4	9	2	3	14	8	0	2	0	0
	FA	0	1	2	4	1	0	8	3	0	2	0	0
	MB	2	2	2	3	3	2	13	5	1	0	0	0
Duration (years)	≤2	2	1	5	5	5	1	13	4	0	1	0	0
	(2-4]	0	4	2	9	1	2	15	10	1	3	0	0
	>4	1	3	1	2	0	2	7	2	0	0	0	0
Extractions	Yes	1	2	2	6	1	2	8	6	0	3	0	0
	No	2	6	6	10	5	3	27	10	1	1	0	0
Retrusion before (m.t.a.)	Yes	0	1	1	2	0	1	1	1	0	1	0	0
	No	3	7	7	14	6	4	34	15	1	3	0	0
Crossbite	Yes	1	2	3	2	1	0	10	2	0	1	0	0
	No	2	6	5	14	5	5	25	14	1	3	0	0
Overjet (mm.)	≤6	2	4	5	11	4	4	25	9	0	4	0	0
	>6	1	4	3	5	2	1	10	7	1	0	0	0
Overbite (mm.)	≤-2	0	0	0	0	0	0	1	1	0	0	0	0
	>-2	3	8	8	16	6	5	34	15	1	4	0	0
Dental class right	I	1	1	2	4	1	2	6	3	0	2	0	0
	II	2	7	6	12	5	3	29	13	1	2	0	0
	III	0	0	0	0	0	0	0	0	0	0	0	0
Dental class left	I	1	2	2	4	1	3	8	4	0	2	0	0
	II	2	6	5	11	5	2	26	10	1	2	0	0
	III	0	0	1	1	0	0	1	2	0	0	0	0
Skeletal class	I	2	2	4	6	1	1	14	5	1	2	0	0
	II	1	5	4	10	5	3	20	10	0	2	0	0
	III	0	1	0	0	0	1	1	1	0	0	0	0
Growth direction	CCW	4	3	3	5	5	2	17	8	1	0	0	0
	CW	1	1	2	4	0	2	8	4	0	1	0	0
	NEU	1	4	3	7	1	1	10	4	0	3	0	0
Objectives achieved?	Yes	3	4	5	8	6	3	26	9	1	1	0	0
	No	0	4	3	8	0	2	9	7	0	3	0	0
Total		3	8	8	16	6	5	35	16	1	4	0	0

Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; FAMB(Functional appliances combined with multibrackets)/ FA(Functional appliances)/ MB(Multibrackets); CCW (Horizontal growth direction)/ CW (Vertical growth direction)/ NEU (Neutral growth direction)

Table 10c: Prevalence of signs before/after treatment according to patient's characteristics. Nº of patients (III).

The results of the percentage of patients with objective signs for TMD are captured in Tables 11a, 11b and 11c.

As Table 10, this crosstabulation illustrates the distribution of the TMD signs before/after treatment according to various patients' characteristics but this time the results are expressed in percentages.

Table 11a: Prevalence of signs before/after treatment according to patient's characteristics. Percentages (I)

		Max. Opening limitation		Max. laterotrusion to the left		Max. laterotrusion to the right		Protrusion limitation	
		Before	After	Before	After	Before	After	Before	After
Gender	Female	3.16	0.00	5.26	2.11	5.26	1.05	8.42	4.21
	Male	0.00	0.00	1.05	2.11	6.32	1.05	5.26	1.05
Treatment	FAMB	1.05	0.00	2.11	1.05	6.32	2.11	4.21	1.05
	FA	1.05	0.00	1.05	0.00	2.11	0.00	4.21	3.16
	MB	1.05	0.00	3.16	3.16	3.16	0.00	5.26	1.05
Duration (years)	≤2	1.05	0.00	2.11	1.05	2.11	0.00	4.21	2.11
	(2-4]	1.05	0.00	2.11	2.11	5.26	1.05	3.16	2.11
	>4	1.05	0.00	2.11	1.05	4.21	1.05	6.32	1.05
Extractions	Yes	0.00	0.00	3.16	1.05	3.16	0.00	5.26	1.05
	No	3.16	0.00	3.16	3.16	8.42	2.11	8.42	4.21
Retrusion before (m.t.a.)	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	No	3.16	0.00	6.32	4.21	11.58	2.11	13.68	5.26
Crossbite	Yes	1.05	0.00	2.11	0.00	4.21	0.00	4.21	2.11
	No	2.11	0.00	4.21	4.21	7.37	2.11	9.47	3.16
Overjet	≤6	3.19	0.00	5.32	2.13	9.57	2.13	11.70	5.32
	>6	0.00	0.00	1.06	2.13	2.13	0.00	1.06	0.00
Overbite	≤-2	0.00	0.00	0.00	0.00	0.00	0.00	1.06	1.06
	>-2	3.19	0.00	6.38	4.26	11.70	2.13	11.70	4.26
Dental class right	I	0.00	0.00	0.00	0.00	2.11	1.05	2.11	1.05
	II	2.11	0.00	4.21	4.21	8.42	0.00	9.47	3.16
	III	1.05	0.00	2.11	0.00	1.05	1.05	2.11	1.05
Dental class left	I	0.00	0.00	0.00	0.00	2.11	1.05	3.16	1.05
	II	2.11	0.00	4.21	4.21	8.42	0.00	8.42	3.16
	III	1.05	0.00	2.11	0.00	1.05	1.05	2.11	1.05
Skeletal class	I	2.11	0.00	3.16	3.16	7.37	1.05	4.21	2.11
	II	0.00	0.00	1.05	1.05	2.11	0.00	5.26	1.05
	III	1.05	0.00	2.11	0.00	2.11	1.05	4.21	2.11
Growth direction	CCW	2.11	0.00	2.11	2.11	2.11	1.05	2.11	0.00
	CW	0.00	0.00	3.16	1.05	2.11	0.00	3.16	0.00
	NEU	1.05	0.00	1.05	1.05	7.37	1.05	8.42	5.26
Objectives achieved?	Yes	3.16	0.00	5.26	4.21	10.53	1.05	11.58	5.26
	No	0.00	0.00	1.05	0.00	1.05	1.05	2.11	0.00
Total		3.16	0.00	6.32	4.21	11.58	2.11	13.68	5.26

Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; FAMB(Functional appliances combined with multibrackets)/ FA(Functional appliances)/ MB(Multibrackets); CCW (Horizontal growth direction)/ CW (Vertical growth direction)/ NEU (Neutral growth direction)

Table 11a: Prevalence of signs before/after treatment according to patient's characteristics. Percentages (I).

Table 11b: Prevalence of signs before/after treatment according to patient's characteristics. Percentages (II)

		Deflexion of the mandible		Passive translation (out of average)		Pain during passive translation (right)		Pain during passive translation (left)		Endfeeling (different than average)	
		Before	After	Before	After	Before	After	Before	After	Before	After
Gender	Female	27.37	23.16	0.00	0.00	0.00	3.16	0.00	1.05	2.11	2.11
	Male	27.37	18.95	1.05	3.16	0.00	1.05	0.00	1.05	2.11	3.16
Treatment	FAMB	22.11	18.95	0.00	1.05	0.00	2.11	0.00	0.00	2.11	2.11
	FA	8.42	4.21	1.05	0.00	0.00	1.05	0.00	0.00	2.11	2.11
	MB	24.21	18.95	0.00	2.11	0.00	1.05	0.00	2.11	0.00	1.05
Duration (years)	≤2	14.74	7.37	1.05	1.05	0.00	1.05	0.00	0.00	1.05	1.05
	(2-4]	27.37	20.00	0.00	2.11	0.00	3.16	0.00	2.11	2.11	3.16
	>4	12.63	14.74	0.00	0.00	0.00	0.00	0.00	0.00	1.05	1.05
Extractions	Yes	10.53	8.42	0.00	1.05	0.00	2.11	0.00	1.05	1.05	1.05
	No	44.21	33.68	1.05	2.11	0.00	2.11	0.00	1.05	3.16	4.21
Retrusion before (m.t.a.)	Yes	1.05	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00
	No	53.68	42.11	1.05	3.16	0.00	3.16	0.00	2.11	4.21	5.26
Crossbite	Yes	14.74	9.47	1.05	0.00	0.00	1.05	0.00	0.00	1.05	1.05
	No	40.00	32.63	0.00	3.16	0.00	3.16	0.00	2.11	3.16	4.21
Overjet (mm.)	≤6	47.87	35.11	1.06	2.13	0.00	4.26	0.00	1.06	3.19	4.26
	>6	7.45	7.45	0.00	1.06	0.00	0.00	0.00	1.06	1.06	1.06
Overbite (mm.)	≤-2	1.06	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	>-2	54.26	41.49	1.06	3.19	0.00	4.26	0.00	2.13	4.26	5.32
Dental class right	I	7.37	5.26	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00
	II	44.21	32.63	0.00	3.16	0.00	3.16	0.00	2.11	3.16	4.21
	III	3.16	4.21	1.05	0.00	0.00	0.00	0.00	0.00	1.05	1.05
Dental class left	I	8.42	5.26	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00
	II	43.16	32.63	0.00	3.16	0.00	2.11	0.00	2.11	3.16	4.21
	III	3.16	4.21	1.05	0.00	0.00	1.05	0.00	0.00	1.05	1.05
Skeletal class	I	28.42	18.95	0.00	2.11	0.00	3.16	0.00	1.05	1.05	2.11
	II	21.05	16.84	0.00	1.05	0.00	1.05	0.00	1.05	2.11	2.11
	III	5.26	6.32	1.05	0.00	0.00	0.00	0.00	0.00	1.05	1.05
Growth direction	CCW	25.26	18.95	1.05	1.05	0.00	2.11	0.00	2.11	3.16	4.21
	CW	12.63	10.53	0.00	1.05	0.00	0.00	0.00	0.00	1.05	1.05
	NEU	16.84	12.63	0.00	1.05	0.00	2.11	0.00	0.00	0.00	0.00
Objectives achieved?	Yes	42.11	30.53	1.05	3.16	0.00	3.16	0.00	2.11	3.16	4.21
	No	12.63	11.58	0.00	0.00	0.00	1.05	0.00	0.00	1.05	1.05
Total		54.74	42.11	1.05	3.16	0.00	4.21	0.00	2.11	4.21	5.26

Notes: Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; FAMB(Functional appliances combined with multibrackets)/ FA(Functional appliances)/ MB(Multibrackets); CCW (Horizontal growth direction)/ CW (Vertical growth direction)/ NEU (Neutral growth direction)

Table 11b: Prevalence of signs before/after treatment according to patient's characteristics. Percentages (II).

Table 11c: Prevalence of signs before/after treatment according to patient's characteristics. Percentages (III)

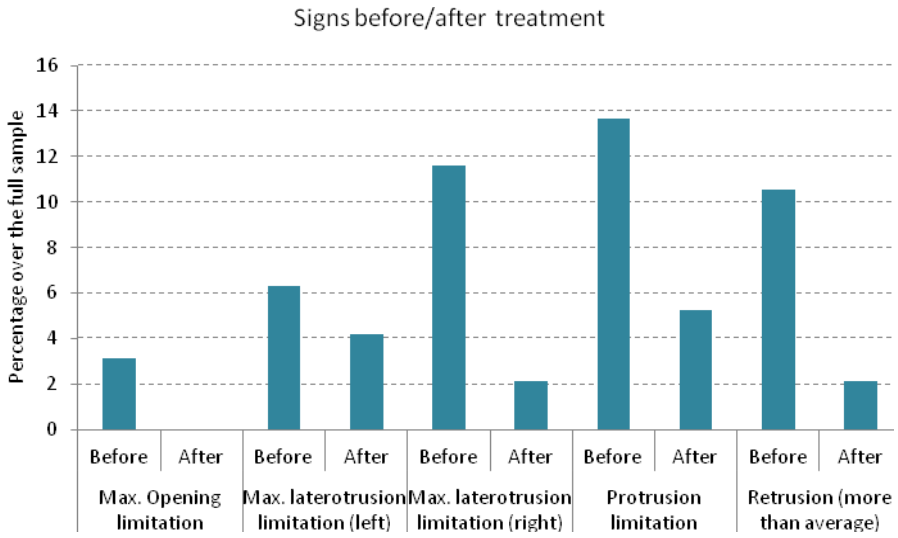
		Clicking		Passive compressions (right)		Passive compressions (left)		Muscle tenderness		Traction and translations		Length of the suprahyoid structures	
		Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Gender	Female	1.05	6.32	1.05	7.37	2.11	4.21	17.89	9.47	1.05	1.05	0.00	0.00
	Male	2.11	2.11	7.37	9.47	4.21	1.05	18.95	7.37	0.00	3.16	0.00	0.00
Treatment	FAMB	1.05	5.26	4.21	9.47	2.11	3.16	14.74	8.42	0.00	2.11	0.00	0.00
	FA	0.00	1.05	2.11	4.21	1.05	0.00	8.42	3.16	0.00	2.11	0.00	0.00
	MB	2.11	2.11	2.11	3.16	3.16	2.11	13.68	5.26	1.05	0.00	0.00	0.00
Duration (years)	≤2	2.11	1.05	5.26	5.26	5.26	1.05	13.68	4.21	0.00	1.05	0.00	0.00
	(2-4]	0.00	4.21	2.11	9.47	1.05	2.11	15.79	10.53	1.05	3.16	0.00	0.00
	>4	1.05	3.16	1.05	2.11	0.00	2.11	7.37	2.11	0.00	0.00	0.00	0.00
Extractions	Yes	1.05	2.11	2.11	6.32	1.05	2.11	8.42	6.32	0.00	3.16	0.00	0.00
	No	2.11	6.32	6.32	10.53	5.26	3.16	28.42	10.53	1.05	1.05	0.00	0.00
Retrusion before (m.t.a.)	Yes	0.00	1.05	1.05	2.11	0.00	1.05	1.05	1.05	0.00	1.05	0.00	0.00
	No	3.16	7.37	7.37	14.74	6.32	4.21	35.79	15.79	1.05	3.16	0.00	0.00
Crossbite	Yes	1.05	2.11	3.16	2.11	1.05	0.00	10.53	2.11	0.00	1.05	0.00	0.00
	No	2.11	6.32	5.26	14.74	5.26	5.26	26.32	14.74	1.05	3.16	0.00	0.00
Overjet (mm.)	≤6	2.13	4.26	5.32	11.70	4.26	4.26	26.60	9.57	0.00	4.26	0.00	0.00
	>6	1.06	4.26	3.19	5.32	2.13	1.06	10.64	7.45	1.06	0.00	0.00	0.00
Overbite (mm.)	≤-2	0.00	0.00	0.00	0.00	0.00	0.00	1.06	1.06	0.00	0.00	0.00	0.00
	>-2	3.19	8.51	8.51	17.02	6.38	5.32	36.17	15.96	1.06	4.26	0.00	0.00
Dental class right	I	1.05	1.05	2.11	4.21	1.05	2.11	6.32	3.16	0.00	2.11	0.00	0.00
	II	2.11	7.37	6.32	12.63	5.26	3.16	30.53	13.68	1.05	2.11	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dental class left	I	1.05	2.11	2.11	4.21	1.05	3.16	8.42	4.21	0.00	2.11	0.00	0.00
	II	2.11	6.32	5.26	11.58	5.26	2.11	27.37	10.53	1.05	2.11	0.00	0.00
	III	0.00	0.00	1.05	1.05	0.00	0.00	1.05	2.11	0.00	0.00	0.00	0.00
Skeletal class	I	2.11	2.11	4.21	6.32	1.05	1.05	14.74	5.26	1.05	2.11	0.00	0.00
	II	1.05	5.26	4.21	10.53	5.26	3.16	21.05	10.53	0.00	2.11	0.00	0.00
	III	0.00	1.05	0.00	0.00	0.00	1.05	1.05	1.05	0.00	0.00	0.00	0.00
Growth direction	CCW	4.21	3.16	3.16	5.26	5.26	2.11	17.89	8.42	1.05	0.00	0.00	0.00
	CW	1.05	1.05	2.11	4.21	0.00	2.11	8.42	4.21	0.00	1.05	0.00	0.00
	NEU	1.05	4.21	3.16	7.37	1.05	1.05	10.53	4.21	0.00	3.16	0.00	0.00
Objectives achieved?	Yes	3.16	4.21	5.26	8.42	6.32	3.16	27.37	9.47	1.05	1.05	0.00	0.00
	No	0.00	4.21	3.16	8.42	0.00	2.11	9.47	7.37	0.00	3.16	0.00	0.00
Total		3.16	8.42	8.42	16.84	6.32	5.26	36.84	16.84	1.05	4.21	0.00	0.00

Notes: Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; FAMB(Functional appliances combined with multibrackets)/ FA(Functional appliances)/ MB(Multibrackets); CCW (Horizontal growth direction)/ CW (Vertical growth direction)/ NEU (Neutral growth direction)

Table 11c: Prevalence of signs before/after treatment according to patient's characteristics. Percentages (III).

Figs. 11a, 11b and 11c graphically illustrate the frequency of objective signs for TMD in percentages.

Figure 11a: Frequency of objective signs for TMD. Percentages



Notes: Max.:maximal

Figure 11a: Frequency of objective signs for TMD. Percentages.

Figure 11b: Frequency of objective signs for TMD. Percentages

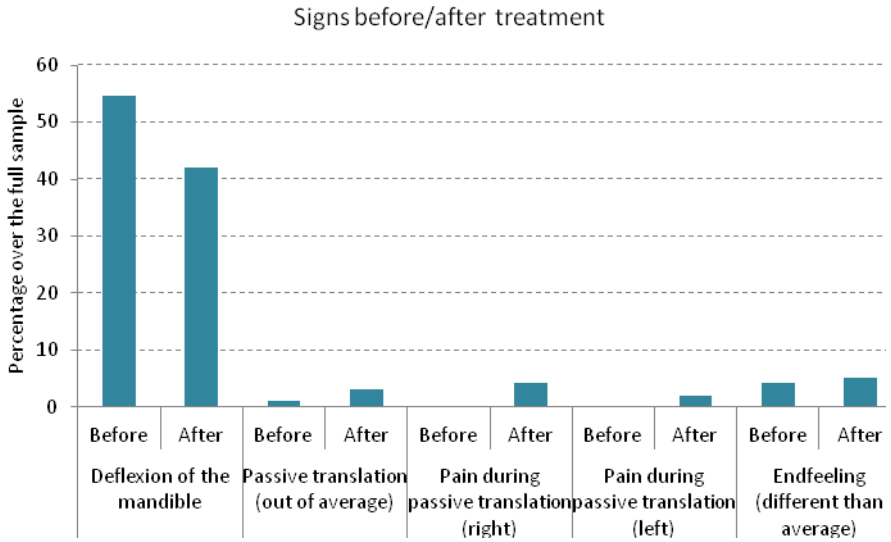


Figure 11b: Frequency of objective signs for TMD. Percentages.

Figure 11c: Frequency of objective signs for TMD. Percentages

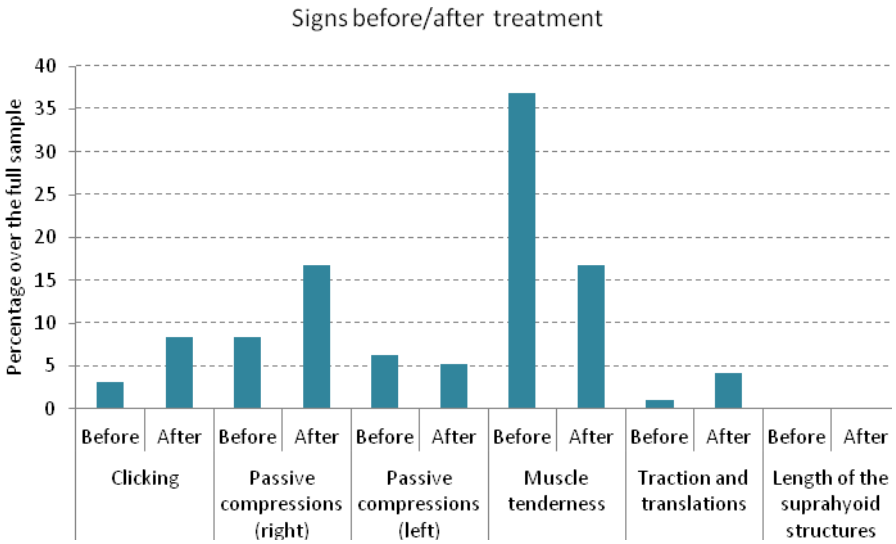


Figure 11c: Frequency of objective signs for TMD. Percentages.

Amongst the signs, the most frequently recorded were deflection of the mandible at mouth opening, muscle tenderness and pain on passive compressions on the right temporomandibular joint, followed by clicking, pain on passive compressions on the left temporomandibular joint and laterotrusion to the right and protrusion limitation.

Maximal opening limitation, laterotrusion to the left limitation, passive translation out of average, pain during passive translation, endfeeling different than average and pain on traction and translations were the least reported symptoms. There were no detected subjects with abnormal suprahyoid structures length. None of the patients presented severe symptoms.

The differences between the percentage of patients with recorded signs before and after orthodontic treatment are recorded in Table 12 and in Fig 12.

Fig. 12 graphically illustrates that the percentage of patients with out of average passive translation, pain during passive translation, different endfeeling than average, clicking, pain on passive compressions on the right TMJ and pain on passive translations increased after the treatment, whilst the percentage of patients who had excentric movements limitation, mandible deflexion on mouth opening, pain on passive compressions on the left TMJ and muscle tenderness decreased after the orthodontic treatment. The differences

are though minimal, with the exception of the big differences according to muscle tenderness.

Table 12: Differences in signs before/after treatment. Percentages

		Max. Opening lim.	Max. laterotru. lim. (left)	Max. laterotru. lim. (right)	Protru. lim.	Retru. (more than average)	Deflex. of the mandib.	Passive translat. (out of average)	Pain during passive translat. (right)	Pain during passive translat. (left)	Endfeel. (diff. than average)	Clicking	Passive compres. (right)	Passive compres. (left)	Muscle tender.	Traction and translat.	Length of the suprah. structures
Gender	Female	-3.16	-3.16	-4.21	-4.21	-4.21	-4.21	0.00	3.16	1.05	0.00	5.26	6.32	2.11	-8.42	0.00	0.00
	Male	0.00	1.05	-5.26	-4.21	-4.21	-8.42	2.11	1.05	1.05	1.05	0.00	2.11	-3.16	-11.58	3.16	0.00
Treatment	FAMB	-1.05	-1.05	-4.21	-3.16	-2.11	-3.16	1.05	2.11	0.00	0.00	4.21	5.26	1.05	-6.32	2.11	0.00
	FA	-1.05	-1.05	-2.11	-1.05	0.00	-4.21	-1.05	1.05	0.00	0.00	1.05	2.11	-1.05	-5.26	2.11	0.00
	MB	-1.05	0.00	-3.16	-4.21	-6.32	-5.26	2.11	1.05	2.11	1.05	0.00	1.05	-1.05	-8.42	-1.05	0.00
Duration	≤2	-1.05	-1.05	-2.11	-2.11	-2.11	-7.37	0.00	1.05	0.00	0.00	-1.05	0.00	-4.21	-9.47	1.05	0.00
	(2-4]	-1.05	0.00	-4.21	-1.05	-2.11	-7.37	2.11	3.16	2.11	1.05	4.21	7.37	1.05	-5.26	2.11	0.00
	>4	-1.05	-1.05	-3.16	-5.26	-4.21	2.11	0.00	0.00	0.00	0.00	2.11	1.05	2.11	-5.26	0.00	0.00
Extractions	Yes	0.00	-2.11	-3.16	-4.21	2.11	-2.11	1.05	2.11	1.05	0.00	1.05	4.21	1.05	-2.11	3.16	0.00
	No	-3.16	0.00	-6.32	-4.21	-10.53	-10.53	1.05	2.11	1.05	1.05	4.21	4.21	-2.11	-17.89	0.00	0.00
Retrusion after	Yes	0.00	0.00	0.00	-1.05	-10.53	-1.05	1.05	1.05	1.05	1.05	1.05	-1.05	0.00	-2.11	0.00	0.00
	No	-3.16	-2.11	-9.47	-7.37	2.11	-11.58	1.05	3.16	1.05	0.00	4.21	9.47	-1.05	-17.89	3.16	0.00
Retrusion before	Yes	0.00	0.00	0.00	0.00	2.11	-1.05	0.00	1.05	0.00	0.00	1.05	1.05	1.05	0.00	1.05	0.00
	No	-3.16	-2.11	-9.47	-8.42	-10.53	-11.58	2.11	3.16	2.11	1.05	4.21	7.37	-2.11	-20.00	2.11	0.00
Crossbite	Yes	-1.05	-2.11	-4.21	-2.11	-4.21	-5.26	-1.05	1.05	0.00	0.00	1.05	-1.05	-1.05	-8.42	1.05	0.00
	No	-2.11	0.00	-5.26	-6.32	-4.21	-7.37	3.16	3.16	2.11	1.05	4.21	9.47	0.00	-11.58	2.11	0.00
Overjet	≤6	-3.19	-3.19	-7.45	-6.38	-8.51	-12.77	1.06	4.26	1.06	1.06	2.13	6.38	0.00	-17.02	4.26	0.00
	>6	0.00	1.06	-2.13	-1.06	0.00	0.00	1.06	0.00	1.06	0.00	3.19	2.13	-1.06	-3.19	-1.06	0.00
Overbite	≤-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	>-2	-3.19	-2.13	-9.57	-7.45	-8.51	-12.77	2.13	4.26	2.13	1.06	5.32	8.51	-1.06	-20.21	3.19	0.00
Dental class right	I	0.00	0.00	-1.05	-1.05	1.05	-2.11	0.00	1.05	0.00	0.00	0.00	2.11	1.05	-3.16	2.11	0.00
	II	-2.11	0.00	-8.42	-6.32	-8.42	-11.58	3.16	3.16	2.11	1.05	5.26	6.32	-2.11	-16.84	1.05	0.00
	III	-1.05	-2.11	0.00	-1.05	-1.05	1.05	-1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Dental class left	I	0.00	0.00	-1.05	-2.11	-1.05	-3.16	0.00	1.05	0.00	0.00	1.05	2.11	2.11	-4.21	2.11	0.00
	II	-2.11	0.00	-8.42	-5.26	-6.32	-10.53	3.16	2.11	2.11	1.05	4.21	6.32	-3.16	-16.84	1.05	0.00
	III	-1.05	-2.11	0.00	-1.05	-1.05	1.05	-1.05	1.05	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00
Skeletal class	I	-2.11	0.00	-6.32	-2.11	-6.32	-9.47	2.11	3.16	1.05	1.05	0.00	2.11	0.00	-9.47	1.05	0.00
	II	0.00	0.00	-2.11	-4.21	-2.11	-4.21	1.05	1.05	1.05	0.00	4.21	6.32	-2.11	-10.53	2.11	0.00
	III	-1.05	-2.11	-1.05	-2.11	0.00	1.05	-1.05	0.00	0.00	0.00	1.05	0.00	1.05	0.00	0.00	0.00
Growth direction	CCW	-2.11	0.00	-1.05	-2.11	-4.21	-6.32	0.00	2.11	2.11	1.05	-1.05	2.11	-3.16	-9.47	-1.05	0.00
	CW	0.00	-2.11	-2.11	-3.16	-1.05	-2.11	1.05	0.00	0.00	0.00	0.00	2.11	2.11	-4.21	1.05	0.00
	NEU	-1.05	0.00	-6.32	-3.16	-3.16	-4.21	1.05	2.11	0.00	0.00	3.16	4.21	0.00	-6.32	3.16	0.00
Objectives achieved?	Yes	-3.16	-1.05	-9.47	-6.32	-9.47	-11.58	2.11	3.16	2.11	1.05	1.05	3.16	-3.16	-17.89	0.00	0.00
	No	0.00	-1.05	0.00	-2.11	1.05	-1.05	0.00	1.05	0.00	0.00	4.21	5.26	2.11	-2.11	3.16	0.00
Total		-3.16	-2.11	-9.47	-8.42	-8.42	-12.63	2.11	4.21	2.11	1.05	5.26	8.42	-1.05	-20.00	3.16	0.00

Notes: Sample: n=95 except for overbite and overjet: n=94; m.t.a: more than average; Max.:maximal; FAMB(Functional appliances combined with multibrackets)/ FA(Functional appliances)/ MB(Multibrackets); CCW (Horizontal growth direction)/ CW (Vertical growth direction)/ NEU (Neutral growth direction); Lim: limitation; Laterotru: laterotrusion; Protru: protrusion; Deflex:deflexion; Mandib:mandibular; Translat: translation; Diff: difference; Tender: tenderness; Suprah: suprahyoidal

Table 12: Differences in signs before/after treatment. Percentages.

Figure 12: Differences in signs before/after treatment. Percentages

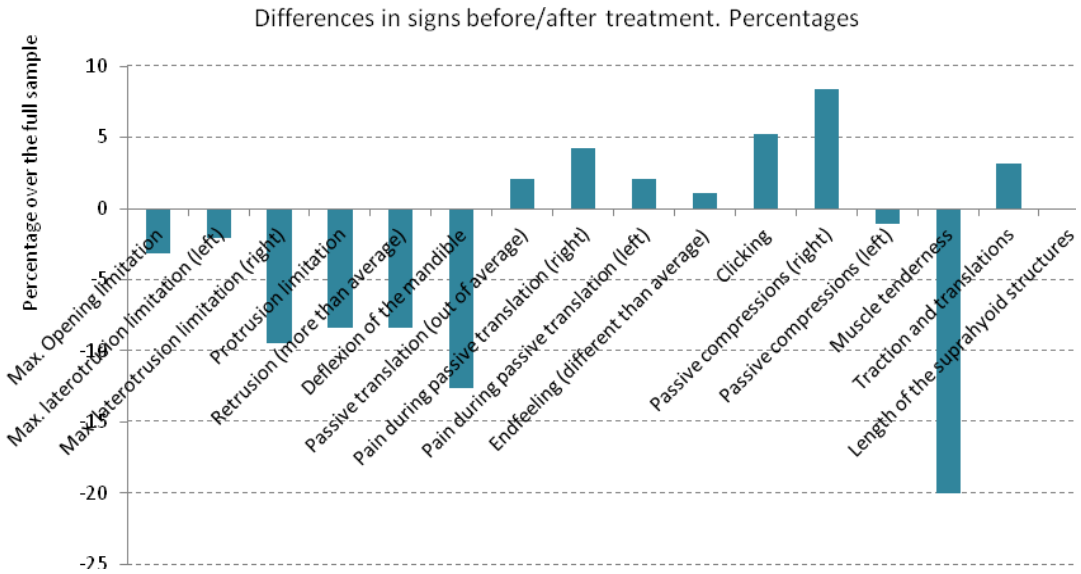


Figure12: Differences in signs before/after treatment. Percentages.

6.4.2. EVOLUTION OF OBJECTIVE SIGNS OF TMD

In order to compare the patients who maintained or changed each sign recorded (before-after treatment) Tables 13a, 13b and 13c and Figs. 13a, 13b and 13c have been designed. Tables 13a, 13b and 13c reflect all the data obtained in percentages, whilst Figures 13a, 13b and 13c only reflect the distribution of the individuals which presented signs at some point.

Most of the patients reported no signs before nor after the treatment (with an exception of patients with mandible deflection at mouth opening and muscle tenderness). These are described as “No-No” (No signs before treatment-No signs after treatment).

Patients who maintained their signs previous to treatment with no variation after treatment, are described as “Yes-Yes” (With signs before treatment- With signs after treatment).

Patients who improved after the treatment are described as “Yes-No” (With signs before treatment- No signs after treatment).

Patients who worsened their previous situation are described as “No-Yes” (No signs before treatment-With signs after treatment).

Table 13a: Evolution of signs before/after treatment. Percentages (I)

Before-After treatment	Max. Opening limitation	Max. laterotrusion to the left limitation	Max. laterotrusion to the right limitation	Protrusion limitation	Retrusion (more than average)
No-No	96.84	90.53	86.32	85.26	87.37
Yes-Yes	0.00	1.05	0.00	4.21	0.00
Yes-No	3.16	5.26	11.58	9.47	10.53
No-Yes	0.00	3.16	2.11	1.05	2.11
Total	100	100	100	100	100

Notes: Sample: n=95; Max.:maximal

Table 13a: Evolution of signs before/after treatment. Percentages (I).

Table 13b: Evolution of signs before/after treatment. Percentages (II)

Before-After treatment	Deflexion of the mandible	Passive translation (out of average)	Pain during passive translation (right)	Pain during passive translation (left)	Endfeeling (different than average)
No-No	36.84	95.79	95.79	97.89	94.74
Yes-Yes	33.68	0.00	0.00	0.00	4.21
Yes-No	21.05	1.05	0.00	0.00	0.00
No-Yes	8.42	3.16	4.21	2.11	1.05
Total	100	100	100	100	100

Notes: Sample: n=95

Table 13b: Evolution of signs before/after treatment. Percentages (II).

Table 13c: Evolution of signs before/after treatment. Percentages (III)

Before-After treatment	Clicking	Passive compressions (right)	Passive compressions (left)	Muscle tenderness	Traction and translations	Length of the suprahyoid structures
No-No	88.42	81.05	89.47	58.95	94.74	100.00
Yes-Yes	3.16	6.32	1.05	12.63	0.00	0.00
Yes-No	3.16	2.11	5.26	24.21	1.05	0.00
No-Yes	5.26	10.53	4.21	4.21	4.21	0.00
Total	100	100	100	100	100	100

Notes: Sample: n=95

Table 13c: Evolution of signs before/after treatment. Percentages (III).

Figure 13a: Evolution of signs before/after treatment

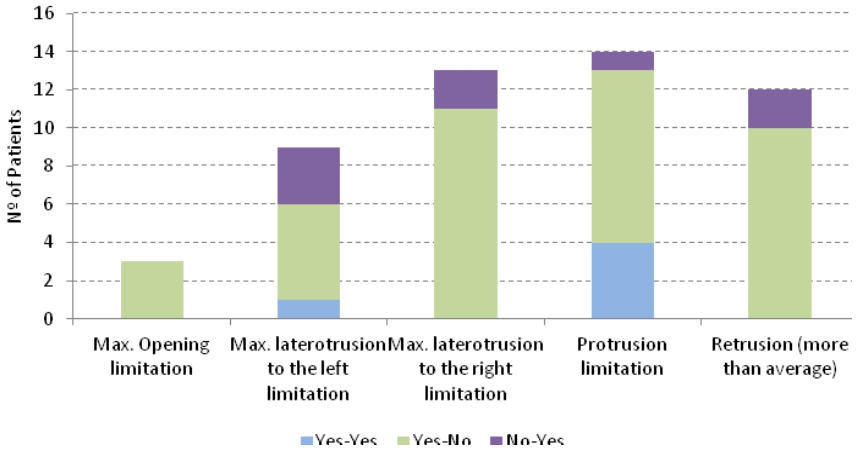


Figure 13a: Evolution of signs before/after treatment. Number of patients (I).

Figure 13b: Evolution of signs before/after treatment

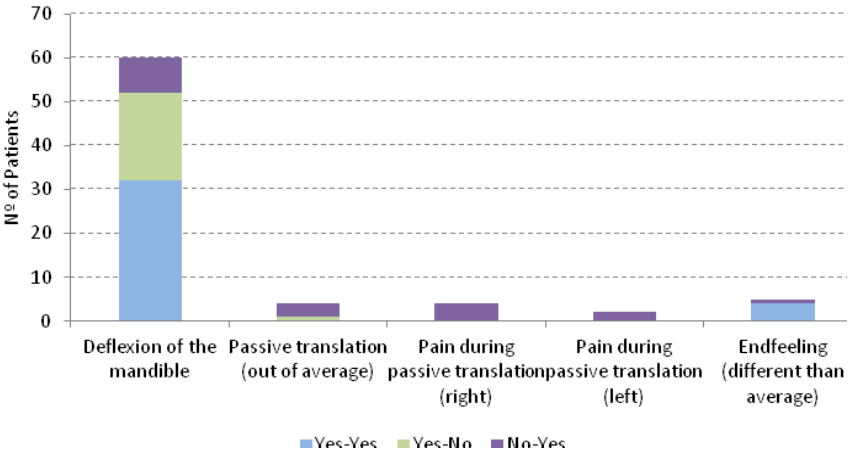


Figure 13b: Evolution of signs before/after treatment. Number of patients (II).

Figure 13c: Evolution of signs before/after treatment

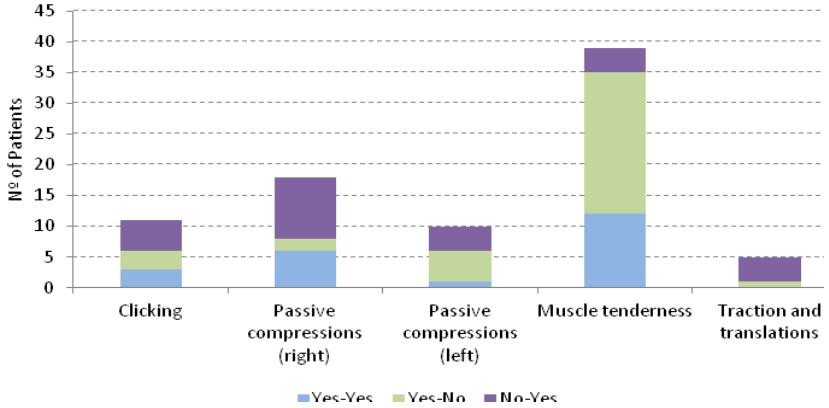


Figure 13c: Evolution of signs before/after treatment. Number of patients (III).

Fig. 14 clearly illustrates that most of the children and adolescents evaluated maintained their previous status according to the exploration, with very slightly variations after the orthodontic treatment; with the exception of muscle tenderness exploration (there was in this case a high 24 percent of

Figure 14: Evolution of signs before/after treatment. Percentages

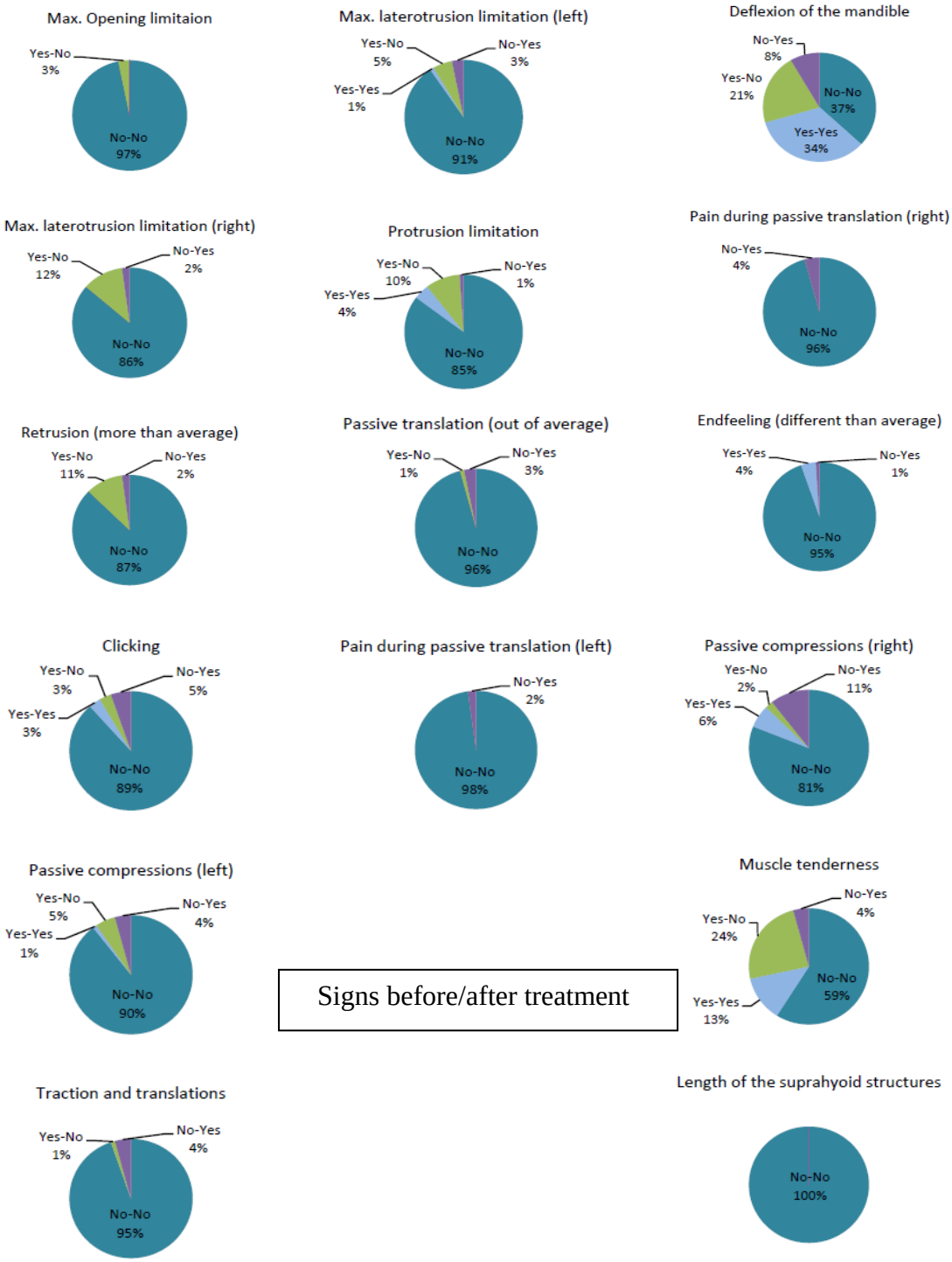


Figure 14: Evolution of signs before/after treatment. Percentages.

Table 15a shows that orthodontic treatment has changed the distribution properties according to ‘maximal opening’ and ‘maximal laterotrusion to the right’. After treatment the movement range increased in both of the cases.

Table 15a: Movement range distribution

Paired Samples Test (t student)								
	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Maximal opening	-2,5737	4,2476	,4358	-3,4390	-1,7084	-5,906	94	,000
Maximal laterotrusion to the left	-,305	1,961	,201	-,705	,094	-1,517	94	,133
Maximal laterotrusion to the right	-,6316	2,0824	,2136	-1,0558	-,2074	-2,956	94	,004

Table 15a: Movement range distribution.

Table 15b shows that orthodontic treatment has changed the distribution properties according to ‘laterotrusion limitation to the right’, ‘protrusion limitation’ ‘retrusion: more than average’ and ‘passive compressions (right)’. After treatment, movement limitation decreased, retrusion range was smaller than at treatment start, and pain on passive compressions on the right TMJ increased.

Table 15b: Movement range distribution

Test Statistics				
	N	Chi-square[a]	Asymp. Sig.	Exact Sig. (2-tailed)
Headpain	95			,687[b]
TJ pain	95			,453[b]
Masti pain	95			1,000[b]
Earsounds	95			1,000[b]
Dizziness	95			1,000[b]
Maximal opening limitation	95			,250[b]
Maximal laterotrusion limitation to the left	95			,727[b]
Maximal laterotrusion limitation to the right	95			,022[b]
Protrusion limitation	95			,021[b]
Retrusion (m.t.a.)	95			,039[b]
pas_trans_ave_b & pas_trans_ave_a	95			,625[b]
Pain during passive translation (right)	95			,125[b]
Pain during passive translation (left)	95			,500[b]
Endfeeling (d.t.a.)	95			1,000[b]
Clicking	95			,727[b]
Passive compressions (right)	95			,039[b]
Passive compressions (left)	95			1,000[b]
Traction and translations	95			,375[b]
a. Continuity Corrected				
b. Binomial distribution used.				
c. McNemar Test				

Notes: m.t.a.: more than average; d.t.a.: different tha average

Table 15b: Movement range distribution.

6.4.3. RELATION BETWEEN PATIENTS' CHARACTERISTICS AND KIND OF PERFORMED TREATMENT AND OBJECTIVE SIGNS OF TMD

The relations between two variables (the different signs and the patients' characteristics before treatment or patients' treatment characteristics) and the direction and strength of such a relation are represented in Tables 16a, 16b and 16c.

Table 16a: Spearman's rank correlation coefficient between patients' characteristics and signs before/after treatment (I)

	Max. opening limitation		Max. laterotrusion limitation (left)		Max. laterotrusion limitation (right)		Protrusion limitation	
	Before	After	Before	After	Before	After	Before	After
Gender	-0.1777*							
Age start treat. (years)								
Duration treat. (years)								
Treatment						-0.1721*		
Extractions			-0.1734*					
Dental class right			0.2339**					
Dental class left			0.2135**					
Crossbite								
Bucalbite								
Overjet (mm.)								
Overbite (mm.)			-0.1847*					-0.2003*
Skeletal class							0.2724***	
Growth direction					0.2155**			0.2823***
Objectives achieved?								
Retrusion before (mm.)				-0.1816*		-0.1971*		
Retrusion after (mm.)						0.1829*		

Notes: Asterisks denote significance level, with ****P<0.01*, ***P<0.05* and **P<0.1*.; Sample: n=95 except for overbite and overjet: n=94

Table 16a: Relation between patients' characteristics and signs before/after treatment (I)

Table 16b: Spearman's rank correlation coefficient between patients' characteristics and signs before/after treatment (II)

	Deflexion of the mandible		Passive translation (mm.)		Pain during passive translation (right)		Pain during passive translation (left)		Endfeeling (diff. than average)		Clicking	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
Gender												
Age start treat. (years)												
Duration treat. (years)	0.2510**											
Treatment												
Extractions			0.2217**									
Dental class right												
Dental class left												
Crossbite												
Bucalbite												
Overjet (mm.)												
Overbite (mm.)												
Skeletal class												
Growth direction			0.1750*						-0.1929*			
Objectives achieved?												-0.1916*
Retrusion before (mm.)			0.1947*									
Retrusion after (mm.)	0.2131**											

Notes: Asterisks denote significance level, with ****P<0.01*, ***P<0.05* and **P<0.1*.; Sample: n=95 except for overbite and overjet: n=94

Table 16b: Relation between patients' characteristics and signs before/after treatment (II)

Table 16c: Spearman's rank correlation coefficient between patients' characteristics and signs before/after treatment (III)

	Passive compressions (right)		Passive compressions (left)		Muscle tenderness		Traction and translations	
	Before	After	Before	After	Before	After	Before	After
Gender	-0.2353**							
Age start treat. (years)					-0.2064**			
Duration treat. (years)	-0.1967*		-0.2021*					
Treatment		-0.2302**						
Extractions								0.2665***
Dental class right								-0.1961*
Dental class left				-0.2593**	-0.1965*			-0.1861*
Crossbite								
Bucalbite								
Overjet (mm.)								
Overbite (mm.)			0.2089**					
Skeletal class								
Growth direction			-0.1771*					0.1957*
Objectives achieved?		-0.2845***				-0.2176**		-0.2569**
Retrusion before (mm.)								
Retrusion after (mm.)				0.1727*				

Notes: Asterisks denote significance level, with ****P<0.01*, ***P<0.05* and **P<0.1*.; Sample: n=95 except for overbite and overjet: n=94

Table 16c: Relation between patients' characteristics and signs before/after treatment (III)

❖ Groups according to patients' characteristics previous to treatment and their relation with different signs for TMD before and after treatment.

- Patients' gender (divided into two different groups): female or male.
  In relation to gender, it was found that girls before the treatment begun, had more tendency than boys to have a mouth opening limitation, as well as more pain on passive compressions on the right TJ. No statistically significant differences were found in relation to the rest of the signs. The significance disappears in the explorations after orthodontic treatment.

- *Age of treatment beginning (divided into four different groups): 8 years or younger, from 8 years to 10, from 10 to 12 and older than 12 years.*
  It was found that the group of younger patients had a tendency to report more muscle tenderness in the exploration before the treatment. But the age of treatment beginning did not influence the results related to TMD signs obtained after orthodontic treatment.

- *Duration of treatment (divided into three different groups): 2 years or less than 2, from 2 to 4 and over 4 years.*
  It was statistically significant that patients who were longer treated, had more mandible deflexion frequency after being treated.

- *Skeletal Class at the beginnig of the treatment (divided into three different groups): I, II or III.*
  Patients with Skeletal Class III showed more protrusion limitation than patients with Skeletal Class II or I, before the treatment, but the significance disappears after it.
  Patients with Skeletal Class II showed also more protrusion limitation than patients with Skeletal Class I, before the treatment, but the significance also disappears after it.

- *Growth direction (divided into three different groups): neutral growth direction, vertical growth direction or horizontal growth direction.*
  The group of patients with a neutral growth direction showed more laterotrusion limitation to the right but less pain on passive compressions

on the left TJ than patients with vertical growth direction or horizontal growth direction.

After treatment, the patients with neutral growth direction showed more limitation in the protrusive movement, wider passive translation, more normal endfeeling and more pain on traction and translations than patients with vertical or horizontal growth direction. At the same time, patients with a vertical growth direction showed more limitation in the protrusive movement, wider passive translation, more normal endfeeling and more pain on traction and translations than patients with horizontal growth direction.

- *Dental Class at the beginning of the treatment (divided into three different groups): I,II or III. The dental class was separated into right side and left side.*

  Class III (on the right side) patients showed more laterotrusion limitation to the left before the treatment than patients with Angle Class I or II. These patients reported less pain on the TJ on the traction and translations after being treated.

  At the same time, Class II (on the right side) patients showed more laterotrusion limitation to the left before the treatment than patients with Angle Class I. These patients reported less pain on the TJ on the traction and translations after being treated.

  Class III (on the left side) patients showed more laterotrusion limitation to the left and less muscle tenderness before treatment than patients with class II or I. After being treated, these patients reported less pain on passive compressions of the left TJ and less pain on traction and translation than patients with class II or I.

  Class II (on the left side) patients showed more laterotrusion limitation to the left and less muscle tenderness before treatment than patients class I. After being treated, these patients reported less pain on passive compressions of the left TJ and less pain on traction and translation than the class I group.

- *Crossbite at the beginning of the treatment (divided into two different groups): patients with crossbite or patients without crossbite.*

The groups did not show statistically significant differences between them in relation to signs before or after treatment.

- *Buccalbite at the beginning of the treatment (divided into two different groups): patients with buccalbite or patients without buccalbite.*
  The groups did not show statistically significant differences between them in relation to signs before or after treatment.

- *Overjet at the beginning of the treatment (divided into two different groups): patients with an overjet of less from 6 mm. or patients with an overjet over 6 mm.*
  The groups did not show statistically significant differences between them in relation to signs before or after treatment.

- *Overbite at the beginning of the treatment (divided into two different groups): patients with an overbite of less than -2 mm or patients with an overbite of more than -2 mm.*
  The group of patients with deeper overbite showed less laterotrusion limitation to the left that the group with open bite, but they showed more pain in passive compressions on the left TJ before being treated.

❖ Groups according to patients' treatment characteristics and their relation with different signs for TMD before and after treatment.

- *Kind of treatment (divided into three different groups): patients only treated with removal appliances, patients treated with fixed appliances and patients treated with a combination of the last two.*
  On the patients' group treated with fixed appliances it was observed a more pronounced decrease of laterotrusion limitation and a decrease of pain on passive compressions of the right TJ after orthodontic treatment than in the other two groups. At the same time, patients who underwent removal appliances treatment showed more decrease of laterotrusion limitation and more decrease of pain on passive compressions of the right TJ after orthodontic treatment than the group treated with a combination of removal appliances and fixed appliances.

- *Extractions (divided into two different groups): patients treated with extractions and patients treated without extractions.*

  The group treated with extractions showed a wider passive translation and a higher tendency to have pain on TJ traction and translations than the group treated without extractions after being orthodontically treated.

- *Ideal orthodontic objectives achieved (divided into two different groups): patients in which the orthodontic objectives were achieved and patients in which the orthodontic objectives were not achieved.*

  Both groups presented no statistically significant differences between them in relation to jaw excentric movements.

  The group, in which the objectives were achieved, showed less clicking, less pain on passive compressions on the right TJ, less muscle tenderness and less pain on tractions and translations after the orthodontic treatment. This significance is strong in the case of the decrease on pain on passive compressions.

Using the Pearson's Chi-Square Test, statistically significant relationships were found: Patients whose skeletal class was II or III presented more protrusion limitation before treatment than patients with skeletal class I, and patients with a deeper overjet presented more mandible deflexion before orthodontic treatment.

7. Discussion

CHAPTER 7

DISCUSSION

The purpose of this investigation was to study frequency and evolution of temporomandibular disorders (TMD) in young patients, with moderate to severe malocclusions, longitudinally. Furthermore, the frequency of TMD and the relation between patients' characteristics, different treatment modalities and TMD signs/symptoms manifestation, was analized. All the patients received orthodontic treatment and were accurately examined before and after being treated, using a validated tissue specific diagnosis based on manual functional examination (MFA).

7.1. Methodology discussion.

All of the patients were seeking for orthodontic treatment and were treated following the same orthodontic philosophies. No special attempts were made to individualize the orthodontic treatment in the subjects who had complaints of pre-treatment symptoms or signs of TMD. For ethical reasons it was not possible to randomize subjects into orthodontic treated group and non-treated group but, since the subjects were being followed longitudinally, the treatment group could act as its own control. Since epidemiological studies have indicated that the incidence of TMD increases with age[41,42] an attempt was made to narrow down the sample to children and adolescents. The female to male ratio was approximately 1:1.

All the clinical examinations for TMD objective signs followed the same methods (Routine Protocol- Manual Functional Analysis by Dr. Axel Bumann-MFA[6]) and were performed by the same examiners. This circumstance has probably minimised the errors but because of reliability issues, registration from subjective symptoms on complementary questionnaires and clinical registration of TMD signs in the youngest subjects, should always be interpreted with caution.

In this investigation, MFA provides a very practical, non-invasive, radiation-free and accurate TMD diagnose system, with no extra costs for the patient. It has already been used for the examination of young adults[10] and adult patients in many studies[10-17]. However, it has not been used in studies with children or adolescents yet. Provocation by specific clinical procedures is a very important part of diagnostics and is particularly stressed in recent studies which have also used MFA.[11-14] Furthermore, MFA use has been recommended as a screening test for symptoms and signs of TMD before orthodontic treatment.[10,15]

7.2. Results discussion

7.2.1. Subjective symptoms of TMD

7.2.1.1. Subjective symptoms frequency of TMD

The frequency of subjective symptoms registered in the present study is similar to most previous publications and were mostly occasional,[32,42,53] being headache the most frequently recorded.[3] Even though, only individuals with malocclusion took part in this study, the similitude of the prevalence results obtained in other studies [3,32,42,53] done with a greater number of patients, other examinations methods for TMD, and with normal occlusion control groups, is big. Some symptoms frequency as head pain and TJ pain had a slight tendency to increase after orthodontic treatment, whilst masticatory muscles pain and ear sounds decreased. The differences are though minimal and can not be considered relevant since results from questionnaires and interviews have to be interpreted with caution.

7.2.1.2. Evolution-longitudinal comparison of TMD

In relation to the longitudinal comparison of the patients who mantained or changed each subjective symptom, it was found that most of the evaluated children mantained their previous status with very little variations after orthodontics, which also coincides with other studies.[65,83]

7.2.1.3. Relation between patients' characteristics and kind of performed treatment and subjective symptoms of TMD

Unlikely to some other publications[3,39] no statistically significant differences between males and females according to TMD symptoms were found. The age of treatment start, the skeletal and dental class and the overjet did not have an influence on subjective symptoms manifestation either. On the other hand, patients with buccal-bite or deep-bite showed a significant tendency to report more TMD symptoms before treatment. Most of the published studies found certain relation with posterior or anterior crossbite and appearance of TMD[3,64-68] but in this study we only found that patients with crossbite reported less headache before and after treatment, which is a striking result.

According to the kind of treatment performed, patients who were treated with removal appliances or the combination of removal appliances and fixed appliances reported more TJ pain after treatment, which could suggest that patients with severer malocclusions may undergo a more complicated TJ adaptation progress. The duration of the treatment did not show any influence on TMD symptoms manifestation. In relation to patients treated with tooth extractions, statistically significant differences were found, as patients who had had extractions showed a tendency to report more muscle tenderness after the treatment. Henrikson and Nilner[65] also found a higher prevalence of tenderness to palpation in the extraction group, but this could be explained as it could be actually the original growth pattern that selected these subjects for extractions, rather than the extractions themselves.

It is important to notice that some differences were found in relation to treatment finishing: if the ideal orthodontic objectives were achieved, it implied a decrease of the TJ pain reported after the treatment. Roth[99] and some authors found in the Spanish literature, as Bujaldón[118,119], Sánchez Turrión[120], Jiménez-Castellanos[121] and Cebrián[122] considered an incorrect diagnosis and/or an incorrect orthodontic planning a risk factor for TMD. For all of them a perfect case finishing, with correct occlusal guides and optimal function was essential in order to prevent TMD.

The registration of subjective symptoms and clinical signs vary in all studies, and the patients in general, present a higher number of signs[19] which also coincides with the results obtained in this study. Again, subjective symptoms records should always be interpreted with caution.

7.2.2. ECCENTRIC MOVEMENTS DISCUSSION

Maximal values of eccentric movements were recorded before and after treatment. In relation to maximal mouth opening the values tend to increase after the treatment but the patients' values differ widely from each other with a standard deviation of nearly 5mm. Some investigators found that young patients (six years old) already opened their mouth 43-45mm.[6]

Maximal laterotrusion movements to both sides and protrusive movement values also increased after the treatment in our study, but in these cases the deviations were much smaller. The literature reflects, that younger children present in general a slightly wider protrusion values than adult patients, but at the age of ten years, these values get similar to the adult ones.[6]

Various studies have reported that there is no correlation, or just a slight and meaningless correlation, between the extension of active jaw movements and the general joint mobility, and Bumann does not consider these movements relevant in order to make a differential diagnosis of TMD. [6]

Passive translation is the only measure which does not tend to increase after treatment in our study. This endfeel distance coincides with the ones registered in various studies[6] and has a mean of approximately 2,9 mm in the young patients taking part in this study.

7.2.3. OBJECTIVE SIGNS OF TMD

Objective TMD signs were recorded following Bumanns's Routine validated Protocol.

7.2.3.1. Objective signs frequency of TMD

Deflection of the mandible was registered in a stunning high percentage before and after treatment, what was also found by Nilner[48,49] in previous publications. Deflections could have different artrogenous causes as hipo-mobility or hiper- mobility of the condiles in an asymmetrical way. [6]

Muscle tenderness was also widely recorded in this study, especially before orthodontic treatment. Studies done among much bigger samples of Chinese children[54] and Turkish children[55], have shown similar prevalence rates of mandibular pain. However another study among Saudi children, registered joint clicking as the most common TMD sign.[53] It is important to notice though, that most of prevalence studies, evaluate muscle tenderness according to palpation, whereas in Bumanns' protocol, isometric muscle contraction is evaluated, which according to various published studies is more accurate.[6,10-15]

In this investigation, the decrease of muscle tenderness frequency after orthodontic treatment is remarkable and could be explained by a decreased hyperactivity of masticatory muscles during orthodontic tooth movement because of sensitive teeth. It is also suggested that this decrease could be due to improved occlusal stability with less occlusal and functional interferences, and more occlusal contacts.[84] These results were obtained as well, in various investigations and the subject has been being widely discussed.[65,84]

In this study, clicking was recorded in similar percentages to previous investigations.[38,40,48,49,53,54] Even though, only individuals with malocclusion took part in this study, the similitude of the prevalence results obtained in other studies done with a greater number of patients, is big. However, in some other studies clicking happened more often than in ours,[31,53] and in another it was less frequent.[54] All of the clicks recorded in this study were intermediate and implied anterolateral partial disc displacement with repositioning. It is noteworthy that only two patients had clicking at both registrations, which implies that natural fluctuations exist in children and adolescents with clicking. It has been suggested that TMJ clicking is progressive,[65] what fits with the results we obtained.

Pain on TJ passive compressions frequency was relatively common before orthodontics and increased its frequency after treatment. These fluctuations are

in line with the findings of Henrikson et al. [65,84] as they reflected that there was a progression in relation to the appearance of TMD signs. Limitations on eccentric jaw movements were also recorded. Laterotrusion movements and protrusive movements limitations were the most registered, even more than opening movement limitation. Most of the studies though, only valuate mouth opening, and they forget about lateral and protrusion movement recordings,[6] which are important as they tell us abaout the general articular mobility.

7.2.3.2. Evolution-longitudinal comparison of TMD

According to patients' evolution, most of the children and adolescents evaluated maintained their previous status in relation to recorded signs of TMD. A certain percentage from them though, showed either improvement or worsening of clinically registered signs over the years.

As in other studies, it was registered a slight increase of the clicking after the treatment[84] as well as an increased pain feeling during TJ passive compressions. Many different studies which compare orthodontically treated patients with non-treated patients have shown that an increase of TMD signs is expected through the years even without having undergone orthodontic treatments. The findings have shown that individual fluctuations are a fact .[65,84]

Our finding of less mandible deflection after treatment (a big number of patients improved their previous status) and less limitation in mandible eccentric movements remains to be explained. A plausible explanation could be that after treatment, more occlusal contacts are obtained (not only because of the treatment but also because of tooth eruption) and this may result in a more symmetric and stable jaw function. These ideas are however debatable.

7.2.3.3. Relation between patients' characteristics and kind of performed treatment and objective signs of TMD

In relation to gender, it was found that girls before the treatment begun, had more tendency than boys to have a mouth opening limitation, as well as more pain on passive compressions on the right TJ. This registered pain could be

explained by mental factors, as girls may be more sensitive to pain.[3] No statistically significant differences were found in relation to the rest of the signs. The significance disappears in the explorations after orthodontic treatment.

It was found that the group of younger patients had a tendency to report more muscle tenderness in the exploration before the treatment. But the age of treatment beginning did not influence the results related to TMD signs obtained after orthodontic treatment. As in the case of girls, the explanation could be that younger kids may be more sensitive to pain. The desirability of initiating orthodontic measures at an early age is becoming more generally accepted. It seems logical to assume that some malocclusions should be treated early to take advantage of the craniofacial growth and thereby achieve the greatest possible adaptation in function.

It was statistically significant that patients who were longer treated, had more mandible deflexion frequency after being treated. No studies have been found in which the exact duration of treatment was specified for the different signs of TMD, so no data is available in order to make comparisons.

TMD has been associated with Angle Class III.[3] In this study patients who had Angle Class III or II had more TMD signs tendency at the beginning of the treatment than the ones with Class I (the same happened to skeletal class and growth direction) which is in agreement with some earlier published findings. The signs fluctuate after treatment unpredictably. The question of whether these patients should be orthodontically treated in order to prevent TMD development is still open to discussion.[65,84]

Unlikely to other studies published [3] patients with deeper overbite showed more pain in passive compressions on the left TJ before being treated than the ones with openbite. A plausible explanation could be that TJs of patients with deeper overbite could induce more preassure on the retrodiscal complex.

Orthodontic treatment with fixed appliances did not increase the prevalence of signs of TMD. On the contrary, the group treated with multibrackets tended to decrease their TMD signs after treatment in comparison to patients treated with functional appliances or a combination of functional appliances-fixed

appliances. This may suggest that patients treated with functional appliances (most of them activators) may undergo more complicated adaptation on the TJs.

The group treated with extractions showed a wider passive translation and a higher tendency to have pain on TJ traction and translations than the group treated without extractions after being orthodontically treated. This results support the ones obtained by Henrikson and colleagues, who found a numerically higher prevalence on registered signs of TMD in the extraction group, even though their results were unexpected since several other studies had not indicated differences between extraction and non-extraction groups.[65] A plausible explanation for the higher prevalence of TMD in subjects with extractions is that actually, the original growth pattern was what selected these subjects for extractions, rather than the extractions themselves.

The group, in which the ideal occlusion objectives were achieved, showed less clicking, less pain on passive compressions on the right TJ, less muscle tenderness and less pain on tractions and translations after the orthodontic treatment. This significance is strong in the case of the decrease on pain on passive compressions. Roth[99] and some authors found in the Spanish literature, as Bujaldón,[118,119] Sánchez Turrión,[120] Jiménez-Castellanos[121] and Cebrián[122] consider an incorrect diagnosis and/or an incorrect orthodontic planning a risk factor for TMD. For all of them a perfect case finishing, with correct occlusal guides and optimal function was essential in order to prevent TMD.

7.3. Clinical implication

Our finding of individual TMD signs fluctuation over time and that none of the subjects developed severe symptoms of TMD during orthodontic treatment is in line with those of Henrikson et al.[65,84] These fluctuations are of important knowledge for the orthodontist and the general dentist if a patient reports TMD during orthodontic treatment. Patient information that some TMD symptoms may come and go spontaneously and a conservative treatment approach are recommended.

Bumanns' functional analysis[6] is a practical way of making a much more accurate TMD diagnosis in our orthodontic offices, without the high costs of MRI for the patients or radiological exposure. TMD questionnaires for children and adolescents are not enough, as they are based simply on children or parents opinions. Deep clinical TMJ explorations are needed in all patients at orthodontics practices at least before and after orthodontic treatment. According to Bumann, TJs continuously adapt themselves to extern stimulus (87). Most of the patients in our study presented an adaptation of the bilaminar zone to the occlusal changes before and after treatment. It has been proven that TJ structures vary continuously and together with it, the manifestation of TMD signs, with no dependence on orthodontic treatment. According to tissue-specific diagnosis, no individuals with signs of arthritis or arthrosis were found in our sample.

According to Bumman's classifications[6], the most frequent dignosis obtained from our explorations in young patients were: myofascial pain, local capsulitis and partial anterolateral disc displacement with repositioning. The occurrence of the tissue-specific diagnoses of TMD from this study was compared to the results achieved by means of MRI by other authors.[4,9,16]

In all of these cases a conservative approach is recommended. These patients should be followed longitudinally to develop recommendations for adequate treatment planning in the future.

7.4. Limitations of the present study

The sample size in this study was not very large. There were some other limitations such as no control group, but since the subjects were being followed longitudinally, the treatment group could act as its own control (due to ethical reasons, it was impossible to leave an untreated group as all patients were seeking orthodontic treatment). Since epidemiological studies have indicated that the incidence of TMD increases with age, an attempt was made to narrow down the sample to children and adolescents. The age span was even though, relatively large and this could be a disadvantage since reliability issues could occur when investigating the younger subjects. However, from all the patients,

only a few where younger than 8 years, what has probably minimised the errors.

8. Conclusions

CHAPTER 8

CONCLUSSIONS

1. Symptoms and signs of TMD fluctuate substantially over time with no predictable pattern. However, a significant improvement of muscular signs of TMD after orthodontic treatment was found.

2. Signs of TMDs were recorded in approximately half of the present children and adolescents at the examinations, most of them being mild in character. It is noteworthy the whole sample presented moderate to severe malocclusions at treatment beginning.

3. Orthodontically treated subjects do not run an increased risk of developing signs or symptoms of TMD after treatment. According to eccentric movements' evolution, maximal protrusion, laterotrusion and mouth opening movements tend to slightly increase after orthodontic treatment, whereas passive translation movement remains the same and retrusive movement decreases after treatment.

4. No significant associations have been found between patient's characteristics and symptoms or signs of TMD. However, girls, younger patients, Angle class III or II patients or patients with a deep bite, had a tendency to report/show more TMD symptoms/signs before treatment than boys, older patients, or class I patients. The question of whether these patients should be orthodontically treated in order to prevent TMD is still open to discussion, as these correlations are very weak.

5. Patients treated with functional appliances, patients treated with extractions and patients in which it was impossible to obtain a good treatment finishing, may undergo a more complicated adaptation process of the TJs than patients treated with fixed appliances, with no extractions and with a good treatment finishing.

6. Bumanns' functional analysis is a practical way of making a much more accurate TMD diagnosis in our orthodontic offices, without costs for the patients or radiological exposure. TMD questionnaires for children and adolescents are not enough; deep clinical TMJ explorations are needed in all patients at orthodontics practices at least before and after orthodontic treatment.

7. An accurate knowledge of the TMJ is needed for the orthodontic practitioners as many individuals who have or will develop TMD will be coming to their offices. It is important to be able to register and control these problems with the course of time. As symptoms and signs fluctuate widely, a conservative treatment approach is recommended for children and adolescents having symptoms or signs of TMD.

9. Future Perspectives

CHAPTER 9

FUTURE PERSPECTIVES

The sample size in this study was not very big. For future investigations it would be interesting to increase the number of patients.

For ethical reasons, it was impossible to leave an untreated group, as every patient with malocclusion who goes to an orthodontics office is willing to become a treatment. It would be of interest to cooperate with other dental departments, in order to be able to examine other patients with malocclusion who do not wish to be orthodontically treated.

We propose to systematize Bumanns' functional analysis exploration in all patients at orthodontics practices at least before and after orthodontic treatment. Bumanns' functional analysis is a practical way of making a much more accurate TMD diagnosis in our orthodontic offices, without costs for the patients or radiological exposure. An accurate knowledge of the TMJ is needed for the orthodontic practitioners as many individuals who have or will develop TMD will be coming to their offices. It is important to be able to register and control these problems with the course of time.

We recommend a conservative treatment approach for children and adolescents having symptoms or signs of TMD, as symptoms and signs fluctuate widely.

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Appendices

APPENDICES

APPENDIX 1: KIG Classification

Schema zur Einstufung des kieferorthopädischen Behandlungsbedarfs anhand kieferorthopädischer Indikationsgruppen (KIG)

Indikationsgruppe		Grad	Stufung 1	Stufung 2	Stufung 3	Stufung 4	Stufung 5
Kraniofaziale Anomalie		A					Lippen-, Kiefer-, Gaumenspalte bzw. andere kranio-faziale Anomalie (C)
Zahnunterzahl (Aplasie oder Zahnverlust)		U				Unterzahl (nur, wenn präprothetische Kieferorthopädie oder kieferorthopädischer Lückenschluss indiziert)	
Durchbruchstörungen		S				Retention (außer 8er)	Verlagerung (außer 8er)
Sagittale Stufe	distal	D	bis 3	über 3, bis 6		über 6, bis 9 (C)	über 9 (F, C, H)
	mesial	M				0 bis 3 (F, Fe, C)	über 3 (F, Fe, G)
Vertikale Stufe	offen (auch seitl.)	O	bis 1	über 1, bis 2	über 2, bis 4	über 4 habituell offen (H)	über 4 skelettal offen (Fe, C)
	tief	T	über 1, bis 3	über 3 ohne/mit Gingivakontakt	über 3 mit traumat. Gingivakontakt		
Transversale Abweichung		B				Bukkal- / Lingual-Okklusion (F, C)	
		K		Kopfbiss	beidseitiger Q Kreuzbiss (F)	einseitiger Kreuzbiss (F, C)	
Kontaktpunktabweichung Engstand		E	unter 1	über 1, bis 3	über 3, bis 5	über 5	
Platzmangel		P		bis 3	über 3, bis 4 (F)	über 4 (F)	

Alle Zahnangaben sind in mm.

APPENDIX 2: Screening Examination Questionnaire

Herzlich Willkommen zur kieferorthopädischen Beratung

Die Auskünfte über den allgemeinen Gesundheitszustand des Farbenten **sind wichtig für eine adaquate** und risikofreie Behandlung. Sie unterliegen der arztlichen Schweigepflicht **alle übrigen Angaben dem Datenschutz**

Vomame und Familienname des Patienten	Geburtsdatum des Patienten
PLZ & Wohnort	StraBe & Hausnummer
Vomame und Familienname des Versicherten	Geburtsdatum des Versicherten
PLZ & Wohnort	StraBe & Hausnummer

Krankenkasse d. Patiënten	Zweigstelle	Freiwillig versichert? ja □ nein □	Zusätzlich versichert? ja □ nein □ interesssert mich □

Erreichbarkeit:

Fax: Tel. privat: e-mail: Tel. Gesch: mobil:

Name des Patienten-Zahnarztes:

Unsere Praxis wurde Ihnen empfohlen von:

Tätigkeit / Beruf / Arbeitgeber der Eltem *(freiwillige Angaben zu Statistik- / Marketingzwecken)*

Vater:

Mutter:

Zahl de Kinder: Davon bereits in kieferothop. Behandlung: Name des Behandlers:

Falls derzeit in Behandlung beim HNO-Arzt / Logopaden:

Name HNO-Arzt: Name Logopäde:

Indikatoren. die ggf. eine ganzheitliche körperlich-orthopadische Untersuchung nahe legen:

haufige □ Kopfschmerzen □ Gelenkschmerzen □ Migrane □Rückenschmerzen □ Ohrgerausche

□ Konzentrationsschwierigkeiten □ Schwindel □ allgememe Unruhe

Wurde vom Orthopaden eine Beinlängendifferenz festgestellf? □ nein □ ja wann?

Erfolgt(e) aufgrund dessen eine Physiotherapie? □ nein □ ja wann?

Wurden die Mandeln oder Polypen entfernt? Wenn ja, wann?

Krankheiten des Patienten (derzeit bestedende oder chronische Krankheiten)

□Diabetes	□Drüsenstörungen	□Nierenerkrankungen	□Tuberkuiose □Epilepsie
□Rachitis	□Rheuma	□Herzfehler	□Glaukom (erhöhter Augeninnendruck)
□Asthma	□Infektionskrankheiten wie	□Hepatitis	□Aids

Allergien gegen: □AllergiepaB vorhanden

Sonstiges (z B Unfall im Kopfbereich):

Erfolgte bereits eine kieferorthopadische Behandlung?	ja □	nein □
Name des Behandlers:		
Hat der Patient jemals am Daumen oder Finger gelutscht?	ja □	nein □
Hat jemand in der Familie eine ahnliche Zahn(fehl)stellung?	ja □	nein □
Besteht eine Schwangerschaft?	ja □	nein □
Wann erfolgte die letzte Röntgenaufnahme im Kopfbereïch?		
Wünschen Sie ästhetische, nicht sichtbare KorrekturmaBnahmen?	ja □	nein □

Wer gehen davon aus, dass Sie mit Ihrer Unterschrift die Korrektheit der Angaben bestätigen und sich im Falle einer Behandlungsbedürftigkeit (Ihres Kindes) mit der Erstellung der diagnostischen Unterlagen zum Zwecke der Aufstellung eines Heil- und Kostenplans einverstanden erklären

Datum: _____ Unterschrift: _____

APPENDIX 3: Clinical examination form

NAME:	DATUM:	ALTER:
	Anfang Bhdl: Ende Bhdl:	Anfang Bhdl: Ende Bhdl:
Frühbehandlung Hrnb: Hmb+ MB Bhdl: Multiband-Bhdl: MB+ Chirurg. Bhdl: Bhdl Dauer:		
Modelle Analyse: Klasse: Overjet: Overbite:		
FRS Analyse: Skelettale Klasse: Wachtumsrichtung:		
Neutralokklusion mit korrektem Overjet und Overbite nach Bhdl erreicht? JA /Nein		
Anamnese Krankheiten:	Allergien:	
- Kopfschmerzen: - Gelenkschmerzen: - Kaumuskulaturschmerzen: - Ohrgeraäusche: - Schwindel:		—Wo: —- Wo:

APPENDIX 4: "Routine Protocol-Manual Functional Analysis"

("Funktionsanalyse-Routineuntersuchungsprotokoll" by Prof.Dr Axel Bumann.)

Qualitätskieferorthopädie
Isernhagen
Dr. med. dent. Sabine Wolter
Fachzahnarztin fur Kieferorthopadie
Sprechzeïten nach Vereinbarung

MANUELLE FUNKTIONSANALYSE

Routineuntersuchungsprotokoll

Aufnahmedatum:

Erst-befund **Zwischen-befund** **AbschluB-befund**

Aktive Bewegungen, Passive Weiterführung und Endgefühl (Kapsel und Restriktionen)

	Aktiv	Translation R L	Passiv	Schmerz R L	Endgefühl
Mundöffnung					
Laterotrusion li.					
Laterotrusion re.					
Protrusion					
Retrusion					

Endgefühle: Hart ligamentär Zu weich
Zu hart
Zurückfedernd
Knöchem

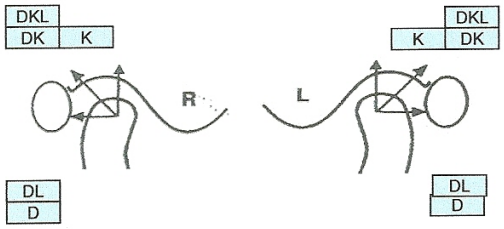
Dyn. Kompression (Gelenkflächen)

□kein Krepitus, kein Schmerz
□Zunahme von Krepitus/Schmerz R/L
□Zunahme von Schmerz + Limitation R/L

Dyn. Kompression und Translation (Knackgerausche)

Dyn. Kompression exkursiv		Dyn. Translation Lateral		Medial	
R	L	R	L	R	L

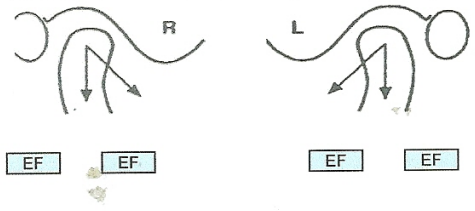
Passive Kompressionen (Biiaminare Zone)



Isometrische Anspannung (Muskeln und Restriktionen)

	Rechts Schmerz	Rechts Kraft	Links Schmerz	Links Kraft
MundschlieBer				
Mundöffner				
Pterygoideus lat re.				
Pterygoideus lat li.				

Traktion and Translationen (Restriktionen)



Lange der suprahyoidalen Strukturen (Restriktionen)

Vertikale Verkürzung:	mm
Sagittale Verkürzung:	mm

APPENDIX 5: Consent form

Dr. med. dent. Sabine Wolter
Fachzahnärztin für Kieferorthopädie

Grauganswеg 21-22
30916 Isernhagen
Tel.: 0511 61659260
Fax.: 0511-61659261

Ich bin damit einverstanden, dass die kieferorthopädischen Daten meines Kindes für medizinische Studienzwecke benutzt werden dürfen.

_____

Isernhagen, Datum — Maria Espinós

_____

Versicherten - Ort / Datum — Unterschrift