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The Thickness of the Occlusal Splint in TMJD Treatment

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Introduction

The occlusal splint is a movable device composed of a hard acrylic material, which separates the two dental arches and is fixed on one arch only.

It is considered a reverse biomechanics way to treat pain and TMJ dysfunction in patients with myofascial pain. The presumed mechanism of action of an intraoral splint is via the relaxation of muscle, either by a change in the muscle itself or by a change in the patient's function-parafunction when the teeth come together.

The compliance with the occlusal splint required personal psychological adaptation as well as physiological rehabilitation like pronunciation and all oral activities, especially after the change of the vertical dimension, which affects the relation between the maxilla and mandible, the swallowing activities, and the tongue's position in the oral cavity.

The social adaptation of the patient and his ability to continue his social activities wearing the occlusal splint 24 hours a day for at least six months (at school, university, work, or with his family) play an essential role for the treatment success and depends on different factors.

In most cases, treatment of such health aware and educated patients faces failures. When questioned many of them answer "The occlusal splint causes social and speech problems, especially during visits, with friends and at work. They are thick and inconvenient, which prompts us to lift it up at times."

What thickness of the splint is acceptable to the patient, from both social and speech points of view and that, is likely to achieve the best results in the sense of decreasing the symptoms?

The aim of our study is to answer this question and firstly to discuss the factors that affect the patient's abiding with the occlusal splint as an important part of the treatment, and secondly treatment's success as a final aim on the other side.

History and Literature review

The disorders of the tempormandibular joints (TMJ) are subjects with a very long history. Great changes happened concerning the idioms and treatments during the past decade.

In 1920, the name of TMJ disorders was associated with two major joint disorders: dislocation and fixation, which were known for a long time ago.

In the 5th century b.c. Hippocrates explained a way to fix the dislocated mandibular bone, which was similar to what the Egyptian's used 2500 year before. That means they differentiated between it and the dislocation that correlates with extra joint problems such as trismus, tinnitus and intra joint problems like ankylosis caused by local infection, trauma or arthritis.

In the past, the TMJ disorders were treated in the same way that other joints in the body were treated. Then the knowledge about its structure, function and the mechanisms of articulation between the mandible and the skull advanced through the study of Vesalius 1543, who was considered to be the first one to reported about a capsule of the TMJ and the joint's disk.

John Hunter [105] reported about the anatomy of TMJ, the motion of mandible, the changes in the toothless patients and after the extraction of the molars and the growth of mandible.

In the second half of the 19th century, surgery appeared to be the treatment of choice concerning the TMJ disorders of fixation, recurrent dislocation which is refractory to treatment.

In the beginning of the 20th century, Axhausen [6] an anatomist, described the anatomy of tissues of TMJ. He reported:

If the teeth were extracted, the condyle will retract upward because of the strong muscular structures that compress's the disc and cause atrophy similar to the one happened to knee lunar cartilage. He noticed the location of the teeth in different cadavers and calculated the pressure on the articulation disc, and dissected the joints and concluded:

“In each time we suspected to find atrophy we found it”.

Then the studies changed their focus from disorders to symptoms since they are caused by the wrong connections between structures, which are caused by malocclusion and teeth loss.

Goodfriend [50], a dentist, described the symptoms caused by TMJ disarticulation after teeth extraction.

Neither the physicians nor dentists paid much attention to this subject even after Coston's notices.

Coston's syndrome

1934 Coston [28] described a syndrome consisting of otologic and sinusoidal symptoms upon noticing 11 cases with TMJ disturbed function which can be noticed often in patient with an overbite and toothless patients.

A- Otologic symptoms:

- Progressive hearing loss with periods of normal or complete hearing loss accompanied by feeling of “stuffy ear” during mealtime.
- Low frequency tinnitus, clicking sound when chewing, vagal pain in or around the ear, severe or mild episodes of dizziness with complete relief when the patient blows and so opening the Eustachian tubes.

B-Sinus symptoms:

Coston [29] reported: The otologic symptoms occurred after the obstruction of the Eustachian tube and tympanic cavity but the sinusoidal ones are:

- Severe headaches located at the top of head, the occipital area and behind the ear (like the pain from the sphenoid sinus) but increases at the end of the day (opposite to the clinical history of sinusitis and just like the ophthalmologic headache), sore throat.
- Burning sensation in the lateral side of the nose and tongue.

C-Diagnosis:

It is based on the existence of malocclusion, loss of molars or bad dental devices which means:

- Overbite
- Flu like moderate hearing loss and episodes of dizziness, improving after the opening of Eustachian tube.
- Tenderness in TMJ, subsiding when a flat body is put between the jaws,
- Headache including the head and eyes despite normal examination of them.

D-Mechanism:

Coston [30] gave an explanation to these symptoms considering Prentiss and Goodfriend past experiments by saying that the hearing loss is caused by occlusion of Eustachian tube and flaccidity of TMJ and its ligaments, which cause the tissues to close the Eustachian tube.

The condyle has been pushed upward towards or between the atrophic or perforated disc or backward towards the tympanic plate and after that medially in each occlusion of the jaw during mastication.

He stated that the reason for the pain was the irritation or pressure induced on the nerves; the vagal pain at the top of the head may be caused by the dura followed by the severe erosion of the bone in the articular fossa, with leaves a thin plate between the condyle and the dura.

The pain of the temporal region is caused by the irritation of the temporal nerve; the pressure on the cord tympanic nerve causes the pain radiating from the side of the tongue.

E-Treatment:

Coston [31] stated that treatment depends in any case on a dental device made to relieve the unusual pressure on the joint and to prevent the disease spreading to the Eustachian tube, condyle and joint capsule.

F-Other symptoms:

Coston [32] added other symptoms: Herpes simplex, tongue pain, glossopharyngeal neuralgia, and trismus.

In 1939, he described a complex composed of neuralgia and hearing loss accompanied by TMJ dysfunction.

1943 the pain was approved, but not the hearing loss and so it has been neglected.

1944 the pain was called TMJ neuralgia.

Kirschner [77], a maxillofacial surgeon, who many scientists criticized like Coston as well anatomologists; stated “before doing the diagnosis of Coston syndrome we should evaluate the symptoms of it precisely and look for other symptoms like, headache, neuralgia, tongue pain, and ear disorders and make a delicate evaluation and diagnosis”.

Despite the fact that Coston faced a lot of criticism, his ideas were accepted in the dental community. 1938 Blecker announced that he treated three cases successfully and so Pippen published about twenty cases in 1943, and after studying hundred cases he said that ninety cases were treated successfully after treating the opposite condyle.

Brussell [15] reported after 10 years of study that there is luxation and subluxation and considered it as partial luxation; the diagnosis was made by palpation, pain and crackles.

In 1951 a book was published named “temporomandibular joint” printed on three chapters concerning the problems of TMJ, the first chapter was written by Zimmerman, he stated that we must get rid of the word “syndrome”.

Second chapter was written by Brodie, he discussed the importance of the chewing apparatus in TMJ disorders.

Hupfau [67] who emphasized the role of solving the problems preventing the complete occlusion, wrote the third chapter.

He reported of intra joint steroid injection in the treatment of TMJ infection,

Axhausen [7] agreed to this treatment.

Ricketts [106] mentioned the importance of Cephalometric radiography in the diagnosis of TMJ disorders. He published an article about the stress and malocclusion effect on TMJ and said that there are exercises to treat these disorders.

Sicher [130] studied the structure and function of the joint and its effect on articulation disorders, so he discussed the disc connection with the condyle and capsule and emphasized the importance of the lateral pterygoid muscle in fixing the joint more than moving it and came to the following results:

- 1- The muscle, which moves the mandible, works as a cooperative harmonic functional unit using a soft biological feedback mechanism.
- 2- The organizing reflexes originate from the nerve endings in the muscles capsule and periodontal ligaments.
- 3- Any disorders in the afferent signals will cause hyperstimulation of the mandibular muscles, strider and trismus. These disorders will be permanent and auto exuberated.
- 3- Intercuspidal correlations, primary contact points and stress are the most common reasons for muscular imbalance.
- 4-The local pain in the retro disc soft tissues originates from the condylar pressure, whatever the one in the surrounding tissues happened from muscular origin.

Hupfauf [67] mentioned that all TMJ disorders should be classified in four categories:

- 1- Traumatic arthritis
- 2- Infectious arthritis
- 3- Rheumatoid arthritis
- 4- Degenerative joint disease.

In addition, he considered them as the origin for all TMJ disorders.

Schwarz [123] stated that the psychophysiological relations should be considered as trigger to the pain episodes. Coston announced that six of his TMJ patients had psychophysiological problems.

As so many physicians noticed that, many patients suffer from complete loss of molars that would be typical for TMJ problems but show no symptoms.

Ramfjord [103] mentioned that the traumatic arthritis of TMJ is a malfunction caused by a disorganized masticular apparatus, stress and occlusal interference (not overbite) which is the most common local cause. He emphasized on the importance of complete and delicate examinations of the patient.

Setz [126] reported that the radiographic diagnosis for the TMJ has great importance in diagnosing its problems through seeing the wrong position of the condyle.

Moyers [91] discussed the use of the Electromyography (EMG) in the differential diagnosis of TMJ disorders.

1956 Jarabak made an EMG study and explained that a spasm of the temporal muscle happened according to TMJ disorders, and it stopped after removing the occlusal interference by elevating the bite.

Carraro [1969] announced that he successfully treated 20 patients after surgical interventions to relieve them from continuous joint pain by making a high incision at the top of the condyle, leaving the rest, the neck and joints intact. This procedure is indicated when all other medical treatments have failed in curing the pain.

He stated that reducing the vertical diameter has no great importance on improving the symptoms, and advised to do supportive treatments and to create balanced functions without any surgical procedures on the tubercle, with emphasis on removing all stress factors to reduce the need for surgical interventions.

He concluded:

The masseters muscles play a predominant role in mastication. Therefore, if the mastication was in normal function, the masseter muscles, the occlusion and TMJ structures should be in normal function and harmony.

Here we can summarize that since 1950 new ideas evolved which focused on the symptoms without paying attention to the causes.

Boyens [13] described this space so the definition of overbite by Coston is not yet accepted because of the great advance in information from Beyron [11] that emphasize the destructive results of neglecting the rest or relaxing positions.

Coston's writings also included some psychiatric issues.

He said that the hearing loss is not the major symptom, but there is the ear ache and described 6 cases with psychoneurotic back round, 1955 some Coston's researches described the masseter pain.

Coston [34] gave the trismus less importance and agreed to do the exploratory surgical procedures for TMJ.

Schwartz [123] treated 2500 patients in TMJ clinic from 1950-1960, from his own experience the results were:

1- The symptoms are not the same that Coston emphasized, he found some of Coston's ones but they were not related to the overbite.

2-It is difficult to associate the symptoms with the increase movement of the condyle towards the tubercle; he considered it abnormal according to false rules because it may be caused by psychological reasons.

3- Schwartz found that TMJ disorders are the same as the joints disorders with the most common one being osteo arthritis followed by rheumatoid arthritis and less likely tumors and fractures.

4-TMJ disorders are painful musclofacial and malfunction syndromes, and its symptoms are similar to other joints such as continuous dull pain with restriction of movement increased with the usage of the joint.

5-Painful malfunction syndrome manifested as clicking, subluxation, dislocation and masseter muscles cramps (because of muscular tension) which are responsible for these symptoms.

Subluxation is the suitable name for the repeated sliding jaw or teeth with no complete occlusion.

6-The disproportional symptoms are followed by a painful limitation of mandibular movement caused by masseter muscles spasms and if it is not self healed or treated it will happen again, therefore a feedback mechanisms will cause such spasms and pain.

The continuous spasms of masseter muscles will be responsible for inducing limitation in mandibular movements as well as pain.

7-It is not well known whether the masseter muscles spasms are induced by nerve impulses from the joint or from the muscles itself. It seems that the two theories are right.

8- No single reason is responsible for the painful dysfunction syndrome but there are multiple reasons including malocclusion. What the patient does by pressing his teeth as a reaction to stress is worse than the malocclusion itself, because the mechanical occlusion will increase the force and change its direction, and most important is the quantity and quality of muscular activity and the patient's reaction to it.

The changing of any occlusion through erosion or improper occlusal reconstructions are the trigger for painful dysfunction syndromes. In some individuals, any tiny change in intramuscular receptors is more important than old malocclusion.

9- Physical examination of the joint muscles and occlusion have been evolved, which helped to obtain a diagnosis and to get all the clinical information's needed which made the clinical practitioner's work easier.

For the masseter muscles, he used the EMG, radiography, history and physical examination.

He stated: We must be careful with the information from the X-ray about the relation between condyle and the fossa temporales because it is only a two dimensional image for three-dimensional movable tissues.

10- Schwarz [124] considerations that in biology and medical sciences there were many techniques and information which made the treatment of TMJ disorders more effective; a lot of these procedures became successful and essential in the treatment. That made us less comfortable to use dentures or correcting occlusion as a definitive solution for its problem; although these new procedures did not induce complete remission but they correct the thoughts that say occlusion is always stable and not changing in same patients from time to time.

11- The spasms could be caused by occlusal interference or primary contact points, on the other hand, the spasm itself may cause occlusion interference points.

Schwartz studies made us hesitate to treat the occlusion and confirmed that before doing any treatment, the patient and his muscles should be relaxed, the occlusion should not be treated at all in some patients, without neglecting the complaint of the patient, whatever his occlusion was.

Moreover, the treatment of TMJ disorders cannot be directed just at the teeth only. Its study considered a great source for the function and mechanisms of occlusion.

Painful Dysfunction syndrome

Since 1949, the treatment of TMJ disorder involved correcting the overbite. With time, the importance of this procedure decreased. It was discovered that the problem was the occlusion; so a solution for this problem was found, but then it was noticed that the selection of treatment, whether it was orthodontic, restorative or selective grinding depends on the physician's experience rather than biological and clinical data (technical consideration more than physiological one).

Investigations:

Schwartz [123] studied 256 cases (mainly women). He reported that there was facial pain accompanying the mandibular dysfunction in 90% of the patients.

In 1955, he described it as dull constant unilateral, ear ache or jaw ache extending some times to head neck and shoulders. The main complaints were limitation of the mandible movement, clicking and repeated condyle luxation. Some patients described momentary sliding, jumping or jaw lock (partially stopped); all these symptoms were accompanied by teeth disarrangement sensations, which are called *subluxation*.

Causes of myofacial pain

Coston mentioned:

The cause of it is pressure on the auriculotemporal nerves. Nevertheless, what the patients described is not similar to neuralgias; it is similar to the one originating from myofacial structures (muscles and fascia). We found that the muscle would be more responsible for such kind of complains.

The question was: Is there any sufficient response in the patients when we use the relaxants to relieve the spasms, trying to correct the function of TMJ?

The use of local anesthetics:

Two studies, one by Schwartz [124] on 20 patients using ethyl chloride spray, the other was by Schulte [115] in 1954 on 40 patients using intramuscular injection. In both, half the patients were treated and compared with the untreated second half; the results were encouraging.

The spray

First group: 7 cured, 2 improved, 1 no changes.

Second group: 1 cured, 1 improved 8 no changes.

Intramuscular injection:

First group: 1cured, 7 improved, 2 no changes

Second group: 2 cured, 2 improved, 16 no changes.

This gave an idea about the source of the pain.

Facial pain and mandibular dysfunction:

The symptoms of facial pain and mandibular dysfunction are not caused by condyle dislocation or overbite but because of the painful dysfunction syndrome (Jankelson [69]).

We noticed that pain corresponds to dysfunction in different cases, so we found that patients with limited mandibular movement and sudden symptoms have had:

- 1- Muscle cramps after waking up because of clenching or gnashing.
- 2- Repeated opening of the mouth, yawning or long dental treatment.
- 3- Changing in occlusion via restorative treatment, selective grinding or after using certain over dentures appliance.

In addition, it was found that second and third factors are related to patient's tendency to muscular spasms, and it was confirmed that the physiological and psychical tendency are more important than the factor itself.

Moyers [92] referred to this factor in his past studies.

Some times the patients suffer from the diagnostic procedures for their psychiatric problem more than the disease itself. The only proof is the moody pattern of patients.

Types of dysfunctions:

- 1- Pain is the most common and is caused by the muscular auto trigger spasms, which originate from feed back mechanism.
- 2- Clicking
- 3- Repeated luxation
- 4- Subluxation
- 5- Painless long standing limitation of movement (rare cases)

TMJ painful dysfunction syndrome

This syndrome appeared like functional derangement in mandibular muscles, clicking; subluxation and repeated luxation, followed by muscular spasms restricting the movements of mandible and causing pain.

When healing does not happened spontaneously or because of treatment, it will be followed by contraction. The symptoms here will be painless limitations of mandibular movements.

By the TMJ Painful Dysfunction Syndrome, malocclusion is just a contributory factor.(Schwartz [122]).

Prevalence according to sex and age:

Schwartz [122] conducted a study on 491 patients, 398 female, 93 male, the results were:

- 1- TMJ is a painful syndrome.
- 2- Female are more than male (83%).
- 3- The symptoms (clicking, luxation, and subluxation) were in women between 3rd to 5th decades, but in the third decade in men.
- 4- The syndrome, which described by Coston was never found.

Dysfunction and organic changes:

Painful TMJ can be reversible, but also can cause some organic changes in the joint.

Frenkel [43] referred to the pain and dysfunction in TMJ:

“As a general rule, patients remarks can be always the same, clicking in TMJ comes with pain sooner or later especially while chewing. Gradually the pain will become worse and correspond with disability in moving the mandible which worsen in the morning (so hard to move the jaw) and the ability to open the

mouth is reduced greatly so the patient is not able to eat the hard food and became thin and weak”.

Steinhardt [37] described such cases together with Foge, they reported:

The problem is in the harmony of the joint, although we cannot imagine TMJ without neuromuscular mechanisms.

Schulte [118] reported:

I found that clicking and other symptoms are the cause of TMJ inflammation, noninfectious degenerative cases, and that clicking could be only one of the symptoms in other serious cases.

Schlegel [110] stated: we must name Coston syndrome as “TMJ arthritis”, and all the symptoms (local, spreading pain, clicking limited movement...act) are due to arthritis.

In 1955 he stated that the pathological changes are of degenerative nature affecting the fibrotic sheet of temporal tubercles, the head of the condyle and the disc.

Degenerative changes:

There is a loose connection between TMJ disorders and its degenerative changes.

Beyron [11] studied 90 TMJ in 45 cadavers between 39-95 year microscopically and showed that 22.2% of cadavers showed degenerative changes uni- or bilaterally without any evidence of TMJ disorders during their life, based on the clinical history.

Granger [57] examined 32 TMJ microscopically with clinical examination of five bodies before death; he noticed that because of the accommodation of the joint with the pathological function you see no positive symptoms with complete destruction of the joint.

Schwartz [122] noted radiographic changes of the condyle and its tubercle without clinical symptoms and in contrast; he saw clear clinical symptoms without radiographic changes.

The muscles:

Schwartz [123] mentioned that most cases of TMJ disorders are because of dysfunction of masseters muscles.

Hunt [166] did not mention the masseters except when he said that in 20% of (94) patients, the muscles on the injured side were weak and atrophied.

Coston [32] described painful muscles in this disease.

Sicher reported, otolagia is caused by masseter muscle's spasms because of clenching. It may be caused by painful stimulations from the joint, also it may originate from the pressure of the mandibular condyle on the posterior attached soft tissues, and may be from muscular origin. The painful response to palpation means it may originate from surrounding joint ligaments.

The painful spots in muscles and mandibular dysfunction were always found in the patients, these disorders were given new names like, myolagia, myositis, fibrositis, and currently myofacial pain is widely used.

Myofacial pain syndrome:

The pain areas in muscles are usually called trigger points.

According to Doms [38] they are a group of sensitive areas which is the trigger point in muscle or tissue with some sort of pain, spasms, tenderness, stiffness, limitation, weakness and a dysfunction in another area called the target area located at distance from the trigger points.

Bonica 1953 described the myofacial syndrome as the most common reason for the disability of skeletal muscles in moving the shoulder muscles, the neck and lower back muscles. It seems that the trigger points give signals that cause spasms and pain, initiating a vicious cycle of pain, spasms, pain despite removing the initial cause.

Jankelson [69] reported

“Spasm is involuntary contractions in one or group of muscles, they vary in there latency from simple unnoticed contractions to severe painful spasm, include most of the muscle fibers, it could be intermittent repeated or longstanding”.

The vicious circle:

Powell [100] stated that the cause of dysfunction is the vicious cycle and explained it:

If we compare the work of muscles with music disc so the disc has its needle always in place and any disturbance will causes the needle to jump from its path which necessities assistance to correct that, as long as the needle is out, the wrong path is longer and the returning is harder.

Therefore, we can break the vicious cycle by injecting local anesthesia in the painful sites or spraying chlorethyl on skin covering the spasmed muscle.

Stress muscle tension:

Stress plays a major role in Myofacial Pain Syndrome, so it should always be kept in mind.

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Sears [125] stated that the accumulation of the intra joint fluids is the reason for clicking.

Sicher [129] reported that clicking means that there is a flaccid disc.

Urbanskaia [140] mentioned that the reason for clicking is both the curving and straightening of the disc during opening and closing of the mouth or roughening of the disc because of pathological changes.

Monson [89] mentioned that irregular or overacting pterygoid muscle causes the disc dislocation that lead to clicking, but this opinion was not supported because of the multimuscular action in TMJ.

Sicher [130] reported:

We must always remember two important facts about the disc, the sufficient anterior connection between the disc and lateral pterygoid muscle, and the loose one between it and the capsule. So if the mandibular muscles became cramped the anterior connection will changes the disc position to the condyle.

In addition, the cause of clicking in the case of reverse muscles action is stability of the disc during mandible backward movement and visa versa or both reasons. This book also discussed mandible dysfunction, occlusion, and the effect on the teeth.

He mentioned the diagnostic procedures like medical history, physical examination, radiological findings, principal of EMG, and how to use it in studying the pathology of nerves, muscles and their connections. It was used to study TMJ with emphasis on the importance of harmony between the mandibular muscles and that any dysfunction can be caused by malocclusion.

In his book, he discussed the differential diagnoses like odontic pain, trigeminal neuralgia, salivary gland pain, ear and sinus pain, head and face vascular pain emotional facial pain, exercises and cortisone treatments.

He reported of using muscle relaxants, surgical procedures, fixing the occlusion, overbites and pass through the psychological considerations in treatment.

Finally, he mentioned all complications of these treatments.

Ramfjord [104], in his book about occlusion; they grouped TMJ disorders in two major categories:

- 1- Acute traumatic TMJ arthritis
- 2- Chronic TMJ arthritis

The first group was described to have sharp and dull pain in TMJ and ear, trismus and deviation of jaw during opening of the mouth.

The second group had gradual onset of unilateral dull pain and limitation with deviation towards the diseased side corresponded with clicking.

Garber [53] described similar symptoms and named them occlumandibular disorders.

Graber [56] used the idiom of TMJ myoarthropathy.

Lasken [82] mentioned delicate criteria of TMJ disorders diagnose and described it. He stated that it has myogenic reasons and called them myofacial dysfunction syndrome (M.P.D.S).

Three of five findings should be found so that it can be said that this patient has this disease:

- 1- Facial pain (unilateral)
- 2- Pain in palpation of the masticatory muscles.
- 3- TMJ clicking during function
- 4- Limitation or deviation in mouth opening.
- 5- Absence of on X-rays finding.

Moreover, Lasken contributed in distributing this idiom.

Unfortunately, many physicians have misused the term (M.P.D.S) to describe any pain or dysfunction in masticator apparatus.

Ferrar [41] discussed the internal disorders of TMJ, disc dislocation that cause clicking, and the disability to open the mouth. Therefore, many practitioners use this term to describe any dislocation.

Because of that, many practitioners were not able to compare the results of their treatments in MPDS patients with TMJ patients because of the wide variety of different idioms used to describe these disorders.

Shore [128] published his book:

Temporomandibular Joint Dysfunction and Occlusal Equilibration:

In it he discussed the physiology of masticator apparatus and its muscles, contraction and relaxation, the TMJ function and teeth, the trigger spots in masticators and SCM, palpation of masticators especially lateral pterygoid , reported about intra joint injection of hydrocortisones, hyalorynidase, acrylic overbite dentures, the importance of occlusion and restorative treatments, the instructions given for TMJ disorders like kind of food, after injections one and about warm bandage and using overbite dentures.

Kenneth Adisman and Louis Jeboucher [1] published the book:

Maxillofacial Prosthetics and TMJ Dental Implants

In (1977) the fifth edition he reported in a research titled TMJ dysfunction – principals of clinical examination.

This article explained the palpation of masticators pterygoids digastrics trapezius muscles, and about the diagnosis of different clicking.

In 1983 M. Franklin Dowleick and Richard W. Katzberg and Clyde A. Helms [65] published their book

Internal Derangement of the Temporomandibular Joint:

They mentioned in it the TMJ normal and abnormal anatomy, evaluation of the patient, the signs and symptoms and so getting diagnosis, the joint appropriate X-ray comparing x-ray with its equivalent anatomical one and mentioning the surgical procedures plus non-surgical ones.

In 1984- Moffit suggested using the diagnostic terms as clinical guide with care in patients to avoid the wrong words leading to wrong diagnosis as well as wrong treatment.

Jeffrey P. Okeson [95] in his book

Management of Temporomandibular Disorders and Occlusion:

described the TMJ and occlusion disorders and ordered them according to special scale discussing the clicking, its progression, the functional disorders of masticator apparatus composed of muscles, teeth, periodontal tissue and their signs and symptoms and the way of capturing the medical history, diagnosis and treatment.

Hassell H, F. Wolf KH and E.M Rateitschak [62] mentioned in their book

Color Atlas of Periodontology:

The functional relation between occlusion and periodontal tissues, TMJ, muscles and central nervous system.

They reported that central nerves system (CNS) could be affected by the patient psychological status.

Froehlich [45] stated:

The stress can be demonstrated as hyperactivity of masticators (clenching, gnashing) so if there was no harmonic occlusion the vicious cycle will be established, and it can be overridden by using the occlusal splint (Michigan), the result will be that the occlusion will get rid of the circle and relief the masticators.

We can do the selective grinding a few weeks later if the stress was eliminated.

The feedback mechanisms can be cut using the splint devises.

The hyperactivity of masticators and temporal muscles is the cause of occlusion trauma.

The use of the splint devise will reduce the activity of the tissues destructive forces that come from clenching and gnashing and turn them into physiological ones spreading around the dental arch.

If we did EMG before and after the application of a splint devise the results will be eliminating of hyperactivity, but if the stress was severe, the patient will clench or gnash upon the devise Here we must use oral physiotherapy or drugs to relief the CNS content.

John .D. Kugh, Gunnar E. Carlsson, George A. Zarb and Norman D. Mohl [93] published a book titled:

A Text Book of Occlusion:

They discussed the occlusion in general, the anatomy and physiology of masticator system and the development of pediatric occlusion from the first year until twelfth.

They mentioned the TMJ, dental ligaments, masticators from the anatomical, physiological, histological aspects, swallowing and chewing, occlusion disorders and its relation to chewing and TMJ dysfunction and then the treatment by occlusal splint, restoring the occlusion by selective grinding, restorative, medical and surgical treatments.

Farrar [40] supposed that the most common cause of failure of treatment is misdiagnosis and that the diagnostic terms ought to be related with tissues pathology and not be based upon the pain.

Hanson [60] mentioned that it is important to have a diagnostic basis because of the vast differences in the diagnoses between clinics; they suggested that the reasons are the differences between terminology and textbooks, which led to different percentages at TMJ clinics.

Bell [8] tried to classify the TMDS in three categories

- 1- Intracapsular disorders
- 2- Capsular disorders
- 3- Extracapsular disorders.

In 1980 the American Academy for Craniomandibular Disorders (AACMD) created a sophisticated theoretical classification.

He reclassified the disorders into five categories:

- 1- Masticator muscle disorders
- 2- Disc interference disorders
- 3- Inflammatory disorders
- 4- Chronic hypo mobility
- 5- Developmental disorders.

Each disorder was classified according to four symptoms:

- 1- Masticators myopathia
- 2- Limitation of movements
- 3- Occlusal Interference
- 4- Malocclusion

In the American Dental Association (ADA) major conference for examination, diagnosis and treatment of TMJ. Chairman and Lasken Held [81], suggested a classification based on Bell's but depending more on reasons than symptoms which are much more confusing so that the classification did not prove ideal.

Bell [9] developed a second classification, which became widely used in the clinics of TMJ, and its terms were included in others classifications such as Clark's [26].

De Laat [37] assumed a way to diagnose TMJ disorders based on synovial joint disease and emphasized on the similarity between TMJ and other synovial joints in the body.

They developed a complex system dividing the TMJD into articulating and non-articulating disorders, inflammatory and non-inflammatory ones etc.

It was taken from another classification developed by the American Rheumatic Association.

In 1990 the AACMD suggested an acceptable classification.

TMJD was reclassified to match the classification of headache that put forward by the international association of headache physicians which gave it three advantages:

- 1- Putting TMJ disorder in appropriate medical classification enables general physician considering it in the general practice.
- 2- Enabled the correct treatment of TMJ disorders.

3- The classification scheme and specific diagnosis criteria will reunion to the terms and so the diagnosis in this system the disorders of TMJ into three groups:

1- Cranial bones disorders

2- Masticators disorders

3- TMJ disorders

Although all the attention is paid on TMJ and masticators disorders, we must keep in mind other diseases affecting the head and neck beside the systemic diseases.

De Bont [36] accepted this idea and emphasized on looking at other diseases before diagnoses of TMJD, beside systemic diseases.

This way will decrease the danger of having a life threatening disease in a patient treated as TMJ patient.

This classification is based on symptoms, signs, reasons, functional disorders, repeatability, other medical classification and the histological origin of the disease. In addition, here the practitioner may choose the suitable one for his information, capability and specialty.

In 1990 Sir Paul Bramley and John Edgar de burg Norman [93], published a book titled

A Text and Color Atlas Of The Temporomandibular Joint Disease- Disorders- Surgery

They discussed the internal disorders of TMJ, their pathology and surgical treatment.

They talked about the osteoarthritis, the problem begun by the perforation of the bone plate distal end so the joint cavity will be continues with subcartilagenous spaces and triggers fibrosis in it. Here sub joint collapse may happen with cyst formation, which endotheliated with bloody fibrotic tissues which can be seen in X-ray.

This means, the degenerative process begins in the cartilage and not in the superficial fibrotic layer.

Although it will be connected to the superficial fibrotic layer, we can notice the myeloid fibrosis and the histological formation of the cyst.

After that, the myeloid fibrosis increases and extends to cover the whole condyle; finally, the erosive changes continue on the surface.

Then reformation of the articulation surface begins with the escalation of fibrotic granulation tissue connected with the synovial ending.

We can notice severe degenerative changes when the disc is adherent or perforated and they suggested, that reformation happened on the anterior and posterior condyle surface, not necessary because the degenerative process but because of age.

The journal of American dental association (JADA) in its 120 textbook third issue published march 1990 titled

“TMJ DISORDERS: The investigation continues”

In this issue multiple epidemic and clinical studies were published and considered as source for treatment of chronic cases

Leon A. Assail and Andrew S. Kaplan [75] published their book:

Temporomandibular Disorders

Diagnosis and Treatment

About the reason of muscular injuries, myopathie, bilateral electrode EMG to compare the muscles on both sides and recorded the results while the mouth relaxed and opened and closed.

They also mentioned the diagnosis, muscle spasms, pain trigger points in muscles and treatment.

In addition, the muscles disorders were considered as a result of the joint internal derangements, because if acute or chronic disorders occur, the muscles which

support and move the joint may be affected and lead to preventive muscular stiffness, which would prevent further damage to the joint.

They noticed disability of moving the jaw with anterior disc displacement without closed lock.

In addition, they discussed the internal disorders, diagnosis, different treatments and final surgical procedures used for TMJD.

Carlson [23] published a book titled

Long Term Effects of Treatment of Craniomandibular Disorders :

They discussed the definition of mandible movements, the role of the general practitioner in evaluation of the occlusion, clicking, mandibular movements, biphasic and the exchange of occlusion and considered that the crepitation and clicking occur because of anterior disc displacement.

They emphasised on treating joint dysfunction, putting the joint elements, masticators to their original place before starting any grinding, restoration, remodeling or any dental interventions etc.

Sabbagh [109] in his book:

Kiefergelenkdysfunktion

Manuela Funktionanalyse Und Physiotherapies, published in Germany, described the manual examination of joint function and determining the injured tissues whether they were bony, muscular or ligament and about some physical exercises used in treatment beside other treatments like bite elevators devices and medical treatment.

Biomechanism of temporomandibular joint

The TMJ is a complex system, with two joints connected to the same bone, each joint working separately with some relation to the other.

Good understanding about its biomechanism enables us to study the masticatory apparatus function and dysfunction.

The TMJ is a combined joint, its structures and function can be divided into two parts:

1st part:

The tissues surrounding the inferior synovial cavity (condyle and disc), because the disc is well attached to the condyle by the medial and lateral ligaments, the only available movement is disc rotation upon the articulating surface of the condyle, though the condylar disc complex is responsible for rotary movement of TMJ.

2nd part:

It is the articulation of the condylar disc complex with the mandibular cavity surface, although the disc is not well attached to the joint, many sliding movements are possible between the surfaces in the upper joint cavity. These movements occurred because the mandibular bone is located anterior, so the sliding movement will be in the upper cavity between upper disc surface and mandibular cavity; the disc then worked as uncalsificated bone between two apparatus, so its function plays a major role in classifying the TMJ as complex joint.

The disc is called meniscus cartilage although it is not meniscus by definition:

The Meniscus Cartilage:

It is a meniscus shape fibro cartilage attached on one side to the capsule and no attachment on the other side extending freely into the intracartilage space.

The disc does not separate the cavity, isolates the liquid or limit the movement but enables the movement between the bone parts.

Usually the meniscus exists in knees, but in TMJ, the disc bulled the articulation surface between superior and inferior joints so it is called articulation disc.

We found in TMJ that the articulation surfaces are not attached to other tissues, though the connection should be always established to stabilize the joint.

The stabilization is insured by the muscles function, which drags the joint (elevator muscles). Even during relaxation, the muscles are in neutralized contraction state, which is called muscle tone.

The width of intra joint space changes according to pressure, so when it decreases the spaces will increases and vise versa (clenching).

The external shape of the disc and its movement enables continuous touching of articular surfaces, which is important for joint fixation. Though when the pressure increased, the condyle fixes itself on the disc middle area, and when the pressure decrease the space will widen and the wider part of the disc will rotate to fill the enlarged space, because the posterior and anterior parts of disc are much wider than the middle. Therefore, the disc can rotate inferiorly and posteriorly to do its function. The direction of its rotation is determined by disc anterior and posterior attachments.

The retrodiscal tissues are connected to the posterior part of the disc and as mentioned the retrodiscal tissues are composed of soft tissues so the function of retrodiscal lamina is to move the disc backward of the condyle surface.

When teeth have contact and the mouth is closed, then the elastic tension on the disc is minimal. When the mouth is open, the condyle is dragged anterior under the tubercle and the retrodiscal lamina becomes tense, causing the disc to move backward; so when the mandible is protruded, the posterior forces on the disc through the retrodiscal lamina will increase.

The anatomical shape and intra joint pressure prevent the disc from excessive backward movements, and when the mandible protrudes to the maximal anterior position and during its return, the superior retrodiscal lamina will drag the disc

backward to rotate upon the condyle, limited by its distinct distance. This is a very important principle to understand the TMJ function.

We must remember that the retrodiscal lamina is the only structure which is able to drag the disc backward when the condyle is fixed.

The superior lateral pterygoid muscle is attached to the disc's anterior edge, so when it is active, the disc is dragged anteriomedially, as the function of this muscle is the anterior protrusion of the disc. Though this muscle does not contribute to the mandible's movements during mouth closing.

When the inferior lateral pterygoid muscle drags the condyle inferiorly, the superior one remains inactive and does not drag the disc anteriorly.

It is important to know the reasons that cause the disc anterior advancement with the condyle in the absence of superior lateral pterygoid muscle activity.

The anterior capsular ligament attached the disc with the articulation anterior surface of the condyle. Moreover, the posterior edge of the disc is attached to posterior edge of articulation surface of condyle by the inferior retrodiscal lamina. Each one of these two ligaments is composed of collagen fibers with only minimal elasticity.

The mechanisms that keep the disc stable and attached with the moving condyle are intra joint pressure and its anatomical shape.

In the normal anatomical form of the disc, the articulation surface of the condyle will settle in the middle area of the disc, between its thick anterior edge and the posterior one.

When the intra joint pressure increases the discal space will shrink and the condyle will be active on the middle portion of the disc.

Moreover, these two factors (anatomical disc form and intra joint pressure) will force the disc to move anteriorly with the condyle during the translatory movement. When the disc anatomical shape changes the insertions of the ligaments on the disc will change and affect the joint's function.

Similar to other muscles, the superior lateral pterygoid muscle will put a slight tension anterior medially on the disc due to its tone.

During rest and mouth closure, this tension will be more than the posterior one by the untended superior retrodiscal lamina. Therefore, during this period (rest position) when the intra joint pressure is low, the discal space is widened and the disc is located anteriorly, which enables it to perform rotational movement at the condyle surface that is connected to the disc posterior and middle regions.

This relation stays during the rotary and simple movements of the mandible. When the condyle moves anteriorly, the tension of superior retrodiscal lamina becomes more than the superior lateral pterygoid muscle; so the disc rotates posteriorly depending on the widening of the discal space. When the condyle returned to the rest position (mouth close) the superior lateral pterygoid muscle tone pulls the disc again to the anterior position depending on the discal space. We notice the importance of the superior lateral pterygoid muscle during strong chewing. When we bite hard food (resistance against closing the mouth), the intradiscal pressure decreases because the closing force will be on the food not the joint, the condyle is advanced, the discal space widened the posterior retraction for superior retrodiscal lamina trying to return the disc to its functional position. That will cause separation of the joints surfaces and so dislocation.

To avoid this, the superior lateral pterygoid muscle contracts anteriorly to reverse the action of the superior lamina so the posterior thick margin stays connected with the joint that make the joint non-stabile during the chewing of hard food. During the mastication of the hard food, and advancement of the intercuspidal interference, the intra joint pressure increases. The discal space shrinks causing the disc to rotate backwards to enable the thin middle area to fill the space. As soon as the chewing ends, the mouth will close and returns into the rest position.

Understanding this mechanism is very important for evaluation of TMJ di

3. Anatomy of temporomandibular joint

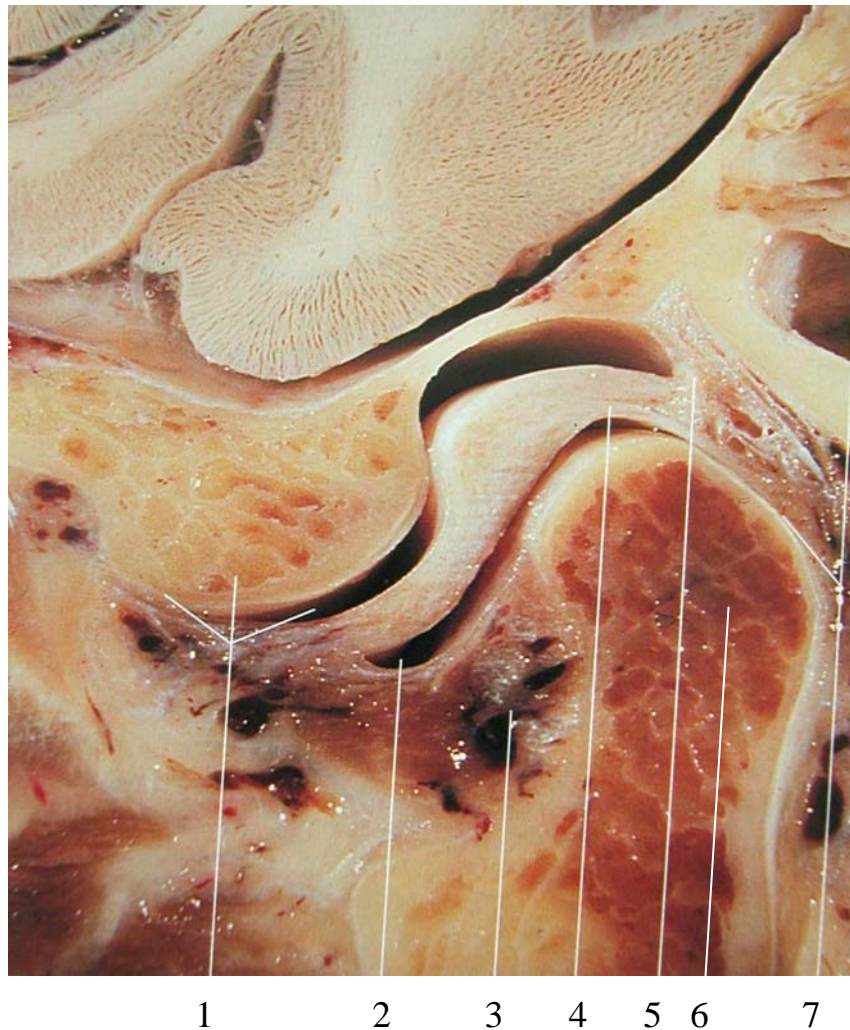


Fig. 1 Medial view of the TMJ with the joint spaces opened Lang [78]

- 1 Articular eminence and upper joint space
- 2 Anterior end of lower joint space
- 3 Lateral pterygoid muscle
- 4 Articular disc
- 5 Posterior end of upper joint space
- 6 Mandible condyle
- 7 Tympanic membrane and posterior end of lower joint space

3.1. Mandibular condyle

It is a pear shape and composed of 4 layers: bone, cartilage, mesenchymic, fibrous structure, with lack of vascular. This histological variety enables us to understand the changes and diversions noticed in examining the TMJ disorders because we can consider them compensatory form changes (the lateral and medial dimensions of the condyle increase) beside the embryologic and genetic effects on the joint in general.

Sonnenburg [136] stated:

The mandibular condyle has an average width of 20.5 mm and an average sagittal diameter of 8,7mm. The neck of the condyle has a sagittal diameter of 7.7 mm, and the condylar process averages 10.5 mm in length.

The condyle contains neither vascular nor nerve endings, the blood supply comes from the synovial fluid Diffusion through its surfaces into the intra joint spaces and the capsule.

The long axis of it directs from the lateral side backwards towards the medial aspect.

The main function for it is transferring the forces on the mandible through the disc and the articulating surfaces to the skull.

Morphologic Types:

Mongini [88] classified the morphology of the mandibular condyle into five basic types with three additional subtypes:

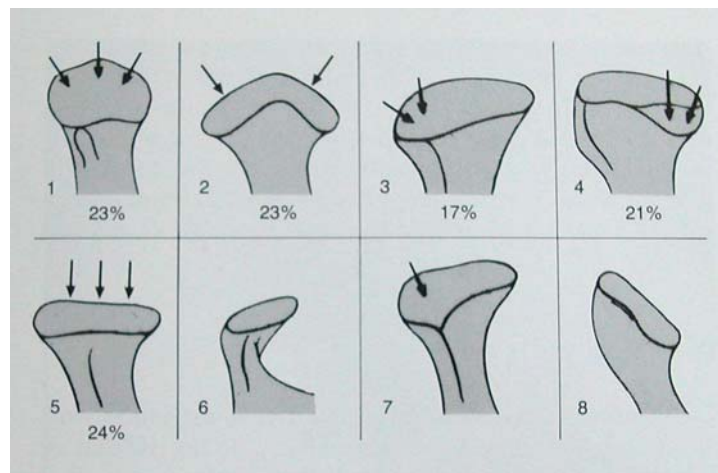


Fig. 2 Various morphologic types of mandibular condyle(Lang [78])

- 1- Type 1 occurs in 23% of individuals 20-53 years of age.
- 2- Type 2 also with a prevalence of 23%, occurs in individuals with heavily worn teeth and a relatively low working side/balancing side index.
- 3- Type 3 condyles (17%) have a steeper lateral slope that is broader and is directed more anteriorly.
- 4- Type 4 (21%) are the converse of type 3, displaying a steeper, anteriorly directed medial slope.
- 5- Type 5 condyles (24%) lack a medial and lateral slope.

Johannes Lang [78] reported in his book (Clinical Anatomy of the Masticatory Apparatus and Peripharyngeal Spaces) the asymmetries and variations of the mandibular condyle.

Marked asymmetry of the mandibular condyle has been observed in 21% of cases.

About the variations he had 12 notices:

- 1- The shape of the mandibular condyle correlates with the nature of the bite. The condyle is higher in jaws with a deep bite and flatter in jaws with a flat bite. The convexity of the mandibular condyle decreases in old age.
- 2- Very rarely, the mandibular condyle projects higher than the tip of the coronoid process when the mandible is in horizontal position.
- 3- In many mandibles the condylar axes do not converge posteriorly but are oriented more transversely.
- 4- The mandibular condyles are never convergent anteriorly.
- 5- Frequently, the condyles have asymmetric orientations so that their longitudinal axes intersect at a point lateral to the midline.
- 6- Sometimes, the condyle slopes steeply toward the posterior surface of the condylar neck.
- 7- Occasionally, there is a sagittal tuberosity on the condyle separating a larger medial plateau from a smaller lateral plateau.
- 8- Less commonly the lateral part of the condyle has a purely orientation, and only the medial portion is curved posteriorly.
- 9- Sometimes, the sharp rim of the mandibular notch does not point to the lateral pole of the mandibular condyle but toward its center, so that half of the condyle is lateral to the plane of the ramus and the other half is medial.
- 10- Frequently, the mandibular condyle may be thinned anteroposteriorly and become platelike with aging.
- 11- Rarely, the mandibular condyle is not superiorly convex when viewed from the front or back; it may be straight or may slope upward to the lateral or medial side.
- 12- Very rarely the mandibular condyle is superiorly convex.

3.2. Articular Disc

It is biphasic concave disc located in the space between the upper surfaces of the condyle and the mandible. It consists of connective fibroid tissues considered as the structure capable of lessening and absorbing the forces transmitted to the skull.

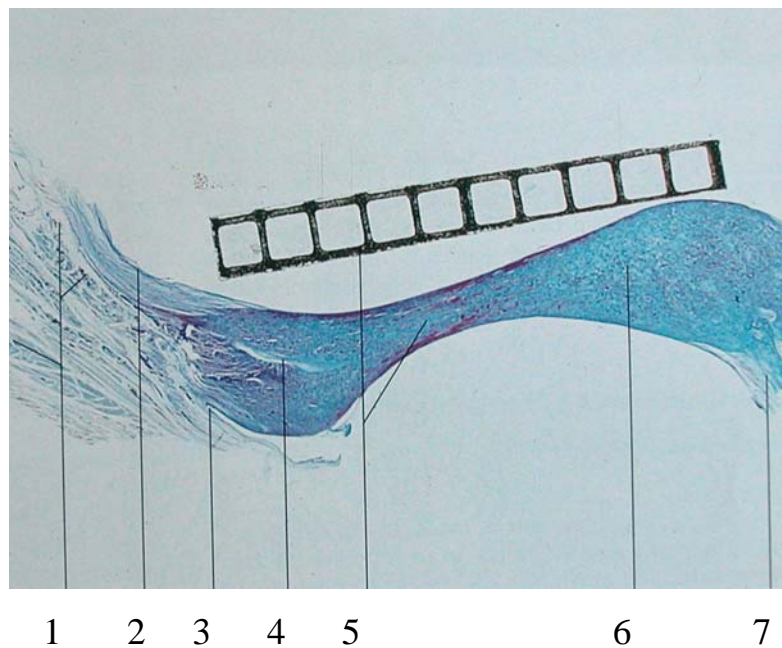


Fig. 3 Articular disc, central zone in longitudinal section Lang [78]

- 1 Lateral pterygoid muscle
- 2 Capsule of upper joint space
- 3 Anterior reflection of lower joint space
- 4 Anterior end of articular disc
- 5 Lang millimeter scale
- 6 Posterior portion of articular disc
- 7 Loose retrodiscal tissue

In newborns, the disc is flat and vasculature with growth it turns into biphasic concave structure thin in the middle and thick peripherally with less vascularity, which is located at the end on the edge especially the posterior one.

That means we cannot find blood vessels and nerve endings except on the edge with disappearing on all the other parts.

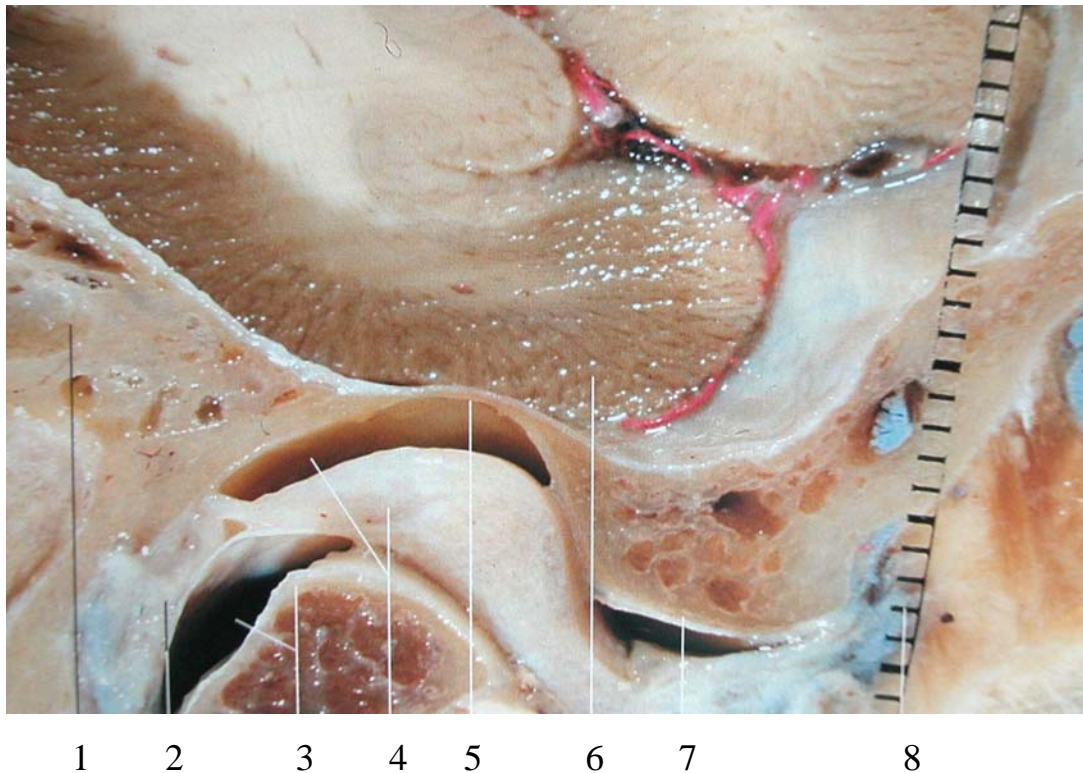


Fig. 4 Thin (0.1 mm) roof of the mandibular fossa Lang [78]

- 1 External acoustic meatus
- 2 Articular disc (bilaminar zone)
- 3 Mandibular condyle and lower joint space
- 4 Articular disc and upper joint space
- 5 Thin roof of glenoid fossa
- 6 Temporal lobe
- 7 Articular eminence
- 8 Millimeter scale

The anatomical shape of the disc is much like the condyle with ligaments attached them to laterally and medially, but anteriorly and posteriorly there are other ligaments like:

- 1- The anterior ligament:

It is the thickest attaching the disc with the anterior edge of capsule and the lateral pterygoid muscle.

2- The middle area:

The thinnest and composes the center of it, located between the posterior inferior surface of the tubercle and the anterior superior one of condyle.

3- Posterior ligament:

The thickest part of the disc and consists the posterior connecting area of the disc with posterior wall of the capsule, composed of two parts:

- a)- superior part: A bundle of elastic fibers attached to the temporal part of the joint between the fossa and its posterior wall
- b)- Inferior part: Tissues full of blood vessels and nerve endings attached to the posterior wall of the condyle.

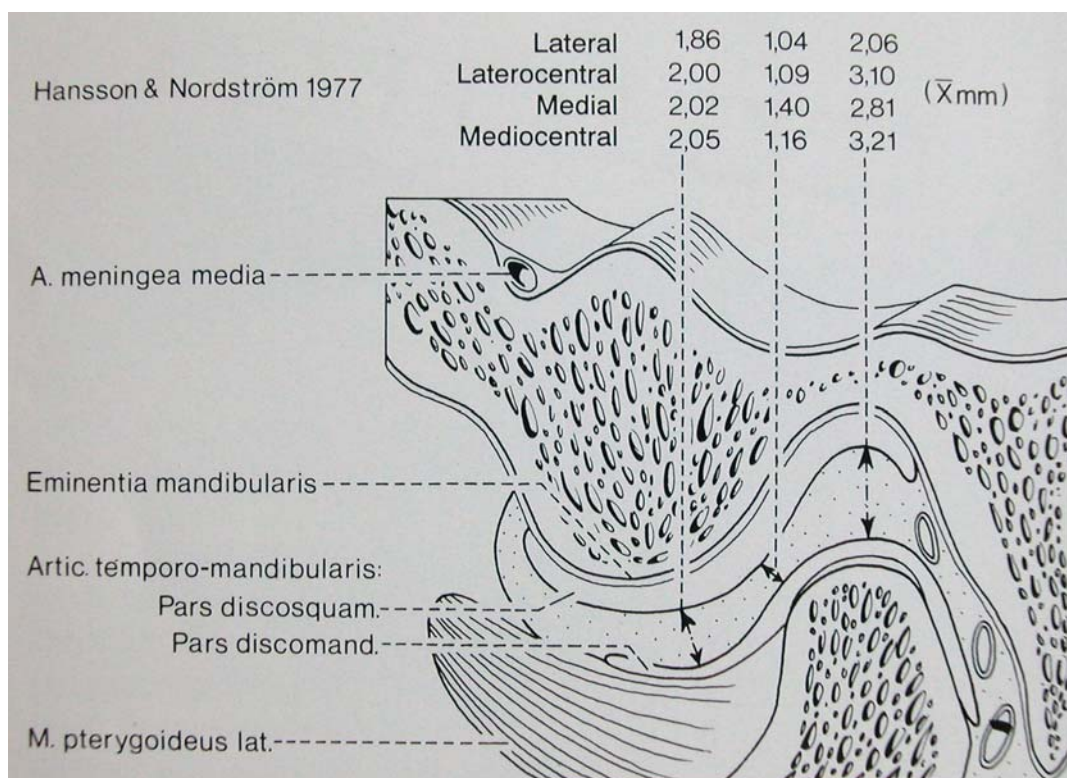


Fig. 5 Articular disc of the TMJ and its upper and lower compartments
Lang [78]

We know that the main function of the disc is absorbing and distorting the forces implicated at TMJ. Also it acts as equilibrating factor which compensates the graphical differences between the condyle and tubercle enabling the mandible's rotating and sliding movement.

The posterior part of the disc consists of two parts:

- 1- The superior part: A horizontal elastic connective tissue directs the disc behind the condyle anterior and posterior during the movements of mandible.
- 2- The inferior part: High elastic tissues located perpendicular to the disc towards the posterior part of mandible; their main function is absorption of the forces implicated during backwards movements of mandible.

The posterior ligaments and part contains:

- 1- Blood vessels to all tissues act to lessen the forces.
- 2- Pressure receptors "Golgi" transmit nerve impulses from the muscles to the CNS to control muscular tone and contraction.

Ishibashi [68] subdivided the medial half of the articular disc into anterior, intermediate and posterior zones.

He showed that the lateral half of the disc is substantially thinner than the medial half. The anterior portion of the disc is attached superiorly to the anterior boarder of the articular eminence; inferior it defines the boundary of the discomandibular joint space.

Hansson [58] and Nordstrom reported that the thickest part of the disc is the posteromedial segment, which measures $(3.2 \pm 0.77\text{mm})$

Lang [78] described the structure of the articular disc:

The articular disc of the TMJ is composed chiefly of collagenous fiber bundles and interspersed cells. Besides wing cells like those occurring in tendons, the articular disc in adults and the elderly contains isolated chondroid cells with faint halos.

Examination of the articular disc in his material generally demonstrated collagenous fibers in the superficial part of the disc, at least in older individuals. Elastic fibers are most abundant in peripheral and posterior zones.

3.3. Articular capsule

Moffett [86] described the rudimentary joint capsule at the 50-mm stage of embryonic development as a subtle cellular condensation on the medial and lateral sides of the joint.

The capsule covers all TMJ content completely and consists of different tissues which vary in elasticity, the external layer is tense, consist of connective fibers close to each other in organized manner, the internal layer is soft and loose.

The main function of the capsule is controlling the joint movements, limiting them through disc and articulating surface borders.

It contains Golgi receptors which transmit nerve impulses to the CNS and so control masticators contraction.

The capsule contains pain receptors called “Nozi receptors” which transmit painful sensations because of pathological, traumatic, inflammatory events in the joint to the CNS and so control muscles activity.

The capsule is attached superiorly with the temporal bone, inferiorly with condyle neck and synovial membrane.

These fluids give the nutritional and metabolic requirements to unvascular surfaces and work as a lubricating factor between the articulating surfaces during function.

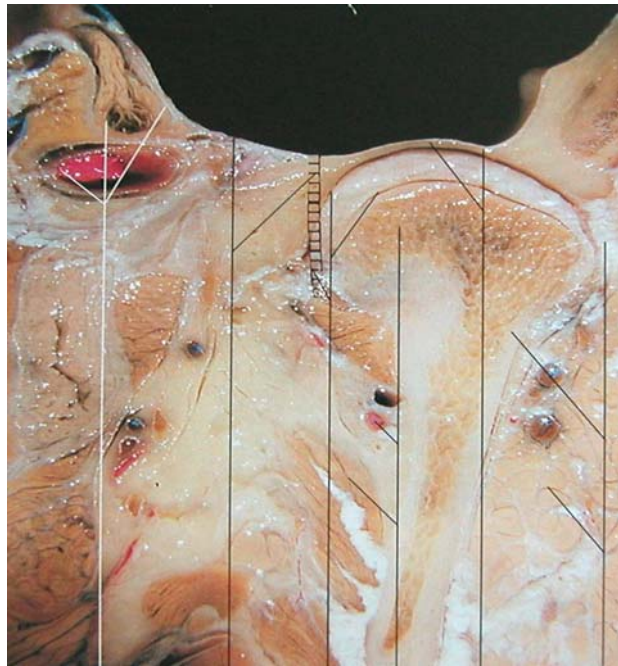
Lang [78] discussed the development of the joint capsule:

Some researchers regard the medial portion of the fossa region as a rest of the cartilaginous primordial cranium. However, the cartilage that lines the fossa and covers the articular eminence probably forms secondarily because of pressure and shear generated by muscular contraction.

3.4. Articular Ligaments

1-Lateral temporomandibular ligament

They are strong ligaments supporting and strengthen the lateral side of the capsule.



1 2 3 4 5 6

Fig. 6 Coronal section of the TMJ Posterior aspect Lang [78]

- 1 Trigeminal ganglion and internal carotid artery
- 2 Middle cranial fossa and millimeter scale
- 3 Upper joint space, lower joint space and medial ligament
- 4 Mandibular condyle, maxillary artery, and medial pterygoid muscle
- 5 Thin floor of middle cranial fossa
- 6 Lateral temporomandibular ligament, condylar neck, and parotid gland

Sicher and DuBru [132] divided the temporomandibular ligaments into deep and superficial layers and also into an anterior and posterior portion.

The superficial layer is a fan shape collagen fibers oblique directed to prevent excessive backward movements of the condyle.

The deep layers restrict backward movements of the disc.

Lang [78] described the function of it:

The temporomandibular ligaments joint with posterior portion of the joint`s capsule to restrain posterior movement of the mandible.

When the mandible is forcibly retruded the fiber bundles of the temporomandibular ligament become extended. The ligament also restrains forward and downward movement of the condyle from the crest of the articular eminence.

When the mandible is in the rest position, the masticatory muscles as well as the joint capsule and temporomandibular ligament are lax. When the mouth is opened by more than 10° , the temporomandibular ligament becomes so extended that further opening of the jaw cannot be accomplished without anterior gliding of the disc and condyle.

2- Medial ligament :

It is attached to the articular disc, located at the border between the posterior wall and medial wall of the joint capsule. Performs the same function as the lateral ligament, but to a lesser degree.

It restrain against excessive posterior displacement of the condyle.

3- Stylomandibular ligament:

It extends from the styloid towards inferiorly and interiorly to mandible angle and it relaxes when the mandible closes and opens widely but tense when the mandible advances. We think that it restricts the advancement of the mandible.

4-Sphenomandibular ligaments:

Originates from the sphenoid and directs anteriorly and inferiorly to ends on the inferior edge of mandible foramen.

4. Blood and nerve Supply

Godzlewski [49] noted that branches of the superficial temporal artery, anterior sympanic artery, and posterior deep temporal artery consistently supply the TMJ.

The external carotid artery is responsible for the blood supply for masticators, TMJ and surrounding soft tissues. This artery is divided at the condyler's neck into internal maxillary and superficial temporal artery.

Mainly the superficial temporal artery supplies the scalp and temporal region.

The afferent nervous supply (motion) , and efferent (sensory) to TMJ and surrounding areas come from trigeminal mandibular branch, the sensory supply for the joint is from auriculotemporal branch and some small fibers go to deep temporal and masticator muscles.

Schmidt [111] discussed the Nerve Supply of the TMJ:

The auriculotemporal nerve normally gives off four articular branches to the TMJ:

1. The first branch arises from the lateral limb of the auriculotemporal nerve, several millimeters past the point where the nerve divides to loop around the middle meningeal artery.
2. The second articular branch arises from the medial limb of the nerve loop. It is approximately 2.1 mm long and 0.1 mm in diameter and enters the joint from the medial side.
3. The third articular branch arises past the origin of the first two. It is approximately 1.3 mm long and 0.08-0.1 in diameter. It arises behind the mandibular condyle and supplies the posterior portions of the capsule
4. The fourth articular branch arises after the nerve converges with the superficial temporal artery. It is 2.2-3 mm long and its caliber does not exceed 0.13 mm. The branch enters the area of attachment of the articular disc from the lateral side, passing within the fibrous layer of the joint capsule.

All four branches supply the superior portion of the joint capsule and the articular disc itself.

The masseteric nerve usually gives off four articular branches

1. The first articular branch of the masseteric nerve usually arises from the foramen ovale. It is typically 5 mm long and about 1 mm in diameter. It pierces the attachment of the lateral pterygoid muscle to enter the fibrous layer of the joint at its anteromedial surface.
2. The second articular branch arises from the first extracranial segment of the nerve. It is approximately 2.8 mm long and 1.5 mm thick. It usually ramifies further before piercing the attachment of the lateral pterygoid muscle to supply the anteromedial part of the joint capsule.
3. The third and fourth articular branches leave the nerve below the zygomatic process. They arise from the portions of the masseteric nerve that supply the superficial layers of the masseter muscle. They enter the disc region of the joint capsule from the rostral side and supply anterolateral portion of the capsule.

All four branches of the masseteric nerve enter the superior joint space or the disc region it-self

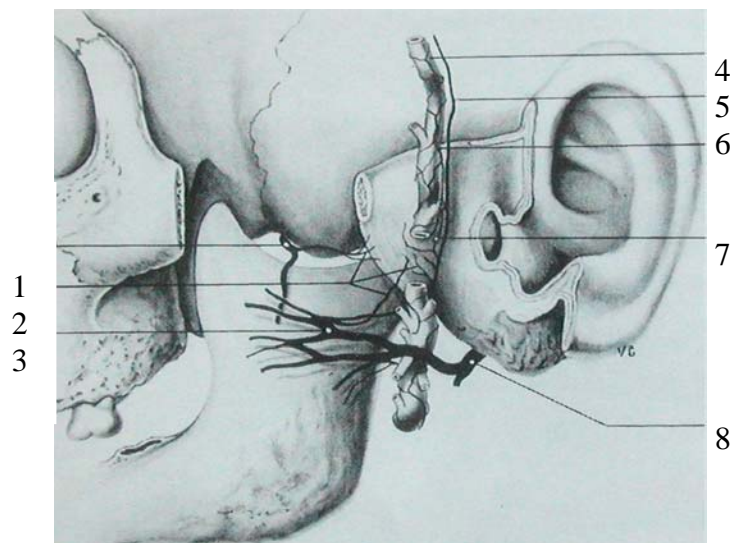


Fig. 7 Nerve supply of the TMJ. Lateral aspect Lang [78]

- | | |
|-------------------------------|-------------------|
| 1 Masseteric nerve | 6 Nerve plexus |
| 2 Articular branches | 7 Vascular branch |
| 3 Parotid plexus | 8 Facial nerve |
| 4 Superficial temporal artery | |
| 5 Articulotemporal nerve | |

Lang 1995 and Tajiri 1976 [78] reported that the posterior deep temporal nerve gives off its articular branch in the area of the infratemporal plane. It is 1.7-4.5 mm long and about 0.08 mm in diameter. The branch enters the posteromedial zone of fusion between the articular disc and fibrous joint capsule. This nerve additionally supplies the periosteum of the infratemporal crest.

5. Muscles

5.1. Masseter Muscle

It is a thick triangle shape muscle composed of two bellies: large superficial, small deep both originate from zygomatic process, the superficial belly ends on the angle of the mandible and its lateral posterior surface, the deep one ends on the lateral side of the head and styloid process.

The two bellies infused anteriorly and separate posteriorly.

Mosolov [90] noted that the masseter muscle is composed of a superficial, middle, and a deep layer. The masseter tends to be tall, narrow in brachiocephalic skulls, short, and broad in dolichocephalic skulls. The tendinous origins of the superficial layer arise from the inferior edge and inner surface of the zygomatic arch and terminate 0.5 cm anterior to the zygomaticomaxillary suture.

Lang [78] examined 50 heads and found that in 15, the anterior end of the muscle was located at the zygomaticomaxillary suture; it was 0.8 cm anterior to it in 23 muscles. The superficial layer of the masseter is inserted onto the lateral surface of the body, angle, and ramus of the mandible.



Fig. 8 Masseteric nerve and artery following removal the superficial layer of the masseter muscle Lang [78]

1 TMJ, lateral temporomandibular ligament, and cervicofacial branch of seventh cranial nerve

2 Masseteric nerve and artery in mandibular notch

3 Intermuscular branches and millimeter scale

4 Mandibular body

5 Buccal fat pad

Function:

The masseter muscle is a powerful elevator of the mandible, closing the jaws and pressing the teeth together, especially in the molar region. The superficial layer descends at right angles over the posterior portion of the curve of spee Lang [78].

The deep fibers run downward and forward when the mandible is in a protruded position, and they can assist the posterior temporales fibers in retracting the mandible into the articular fossa.

5.2. Temporal Muscle

The large fan shape muscle originates from the temporal fosse and lateral skull surface, its fibers tend to meet in one point and pass between the zygomatic arch and lateral surface of skull to end on the coronoid process and head anterior edge.



1 2 3 4 5 6 7 8

Fig. 9 Temporal muscle after removal of the temporal aponeurosis Lang [78]

- 1 Cut edge of scalp
- 2 Posterior, almost horizontal fibers of temporalis
- 3 External ear
- 4 Superior temporal line, origin of temporal aponeurosis
- 5 Inferior temporal line
- 6 Zygomatic arch
- 7 Millimeter scale
- 8 Most anterior temporalis fibers and marginal process of zygomatic bone

Function:

Its function is elevating the mandible and moving it backwards, If the anterior fibers contract the mandible will be elevated.

The middle oblique fibers contributes to elevating and moving it backwards.

The horizontal posterior fibers move the mandible backwards.

The temporalis is the most powerful adductor muscle of the mandible.

Lang [78] Cross-sectional measurements indicate that it can develop an adductive force of 36 kg.

The anterior fibers can exert a protracting force of approximately 2 kg. The posterior fibers can exert a retracting force or an additional adductive force of about 10 kg. Beside their importance for mandibular elevation, the deep fibers of the temporalis assist in lateral deviation of the mandible on unilateral contraction and in protrusion on bilateral contraction. The medially directed components exert a force of approximately 3 kg. The posterior, almost horizontal fibers are important for retrusion.

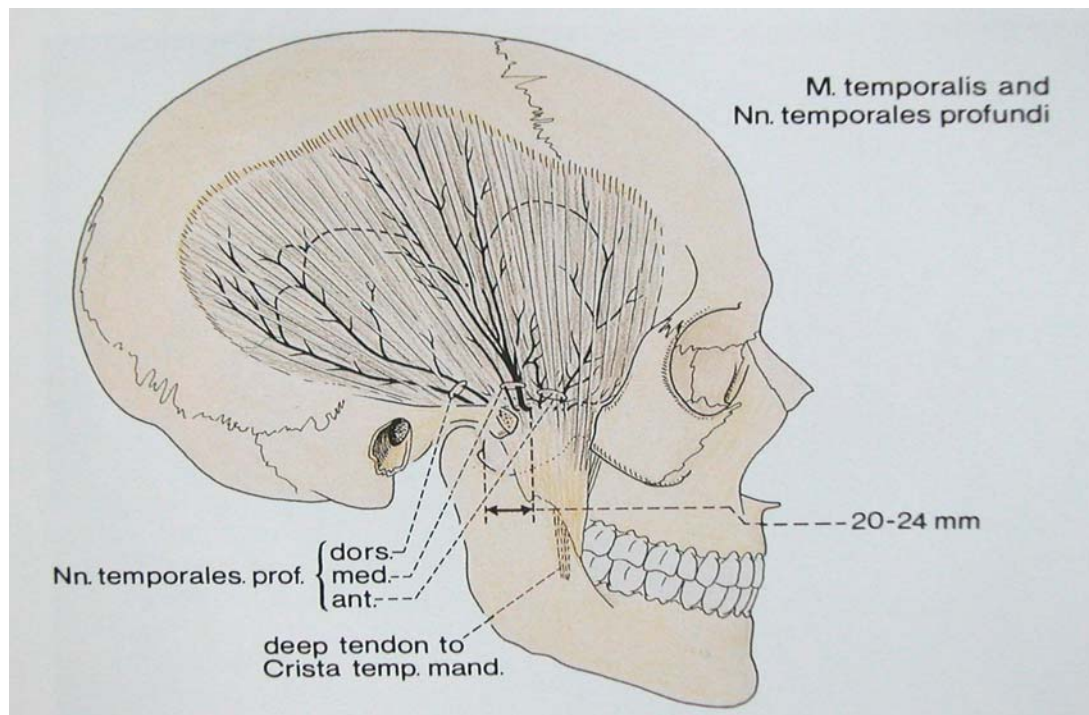


Fig. 10 Nerve supply of the temporalis muscle Lang [78]

5.3. Medial pterygoid muscles

It is located medial of the mandible, originates from the middle part of the lateral pterygoid and leads towards inferior posterior and outside to ends in the middle part of the angle. It is the opposite of the temporales, its fibers meet with the masticators posterior and inferior the angle to support the mandible elevating it.

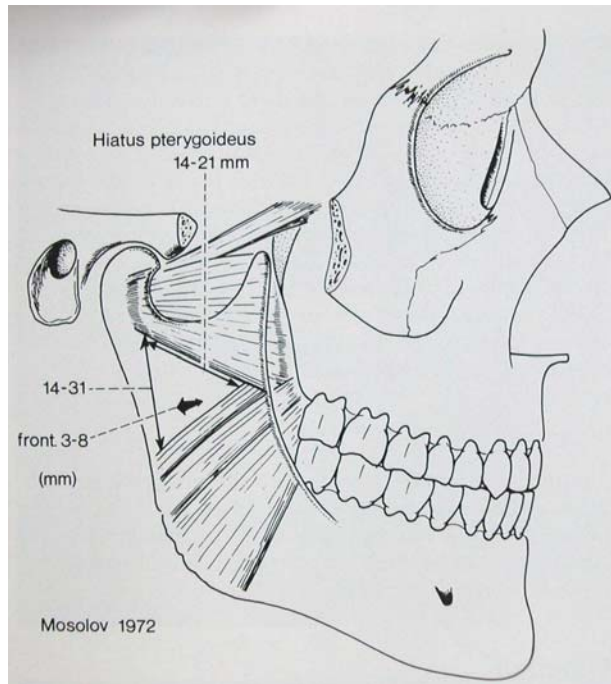


Fig. 11 Pterygoid hiatus. Lang [78]

The medial pterygoid and masseter muscles act together as a sling to suspend the mandibular angle. The fibers of the medial pterygoid, similar to those of the masseter, descend posteroinferiorly at about a 10° angle. This obliquity gives the medial pterygoid an adductive and protrusive action that can generate a force of 15.4 kg for elevation of the mandible and 2.7 kg for protrusion.

The total elevating force of the pterygoid-masseter sling is 43 kg (Schumacher [121]).

5.4. Lateral pterygoid muscle

The lateral pterygoid can pull the mandible condyle and articular disc forward and downward as well as inward along the posterior slope of the articular eminence.

The tensile force exerted by the inferior head has been estimated at 13 KG Schumacher [121]. Electromyographic studies indicate that the superior head contracts during jaw closure and restrains against excessive posterior movement of the articular disc. Its potential force equals 3.2 Kg. EMG findings indicate that the two divisions of the lateral pterygoid function independently of each other. The inferior head function as a synergist of the suprahyoid muscles and displays no EMG activity during jaw closure or swallowing.

The superior head is inactive during jaw opening, but active potential during jaw closure (Lang [78]).

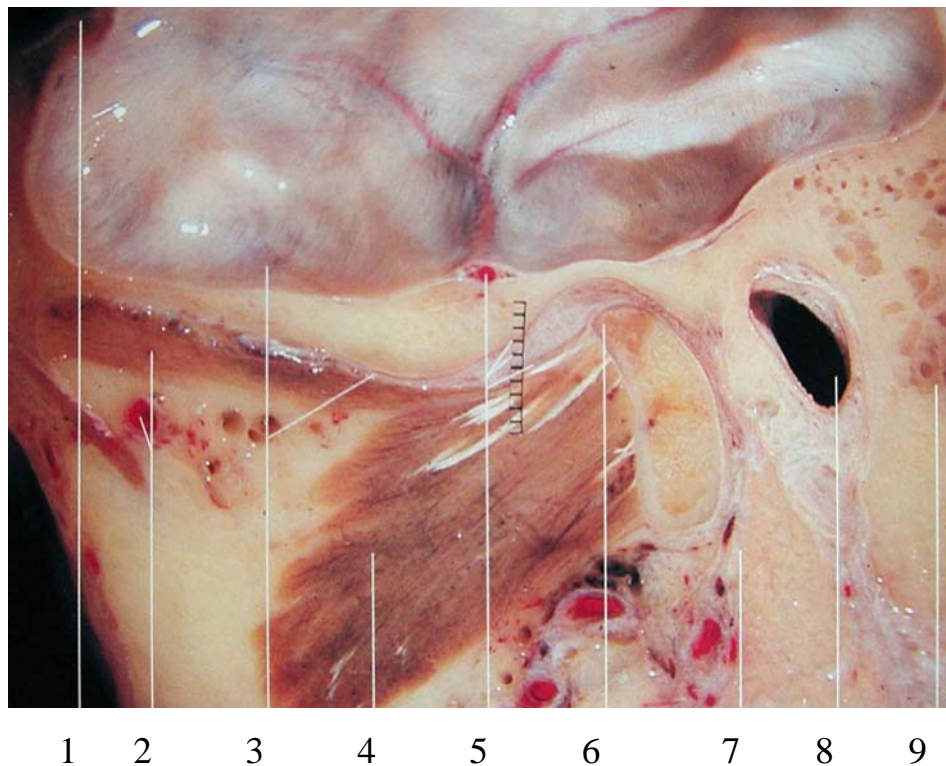


Fig. 12 Oblique (anteromedial to posterolateral) section of the TMJ Lang [78]

- 1 Sphenoidal ridge
- 2 Superior head of lateral pterygoid muscle and maxillary artery
- 3 Floor of the middle cranial fossa and anterior extension of superior joint space
- 4 Inferior head of lateral pterygoid muscle
- 5 Middle meningeal artery and articular disc with millimeter scale
- 6 Mandibular condyle

7 Parotid gland

8 External acoustic meatus

9 Mastoid air cells

It is thought that the superior head of the lateral pterygoid stabilizes the condyle and the disc against the articular eminence, while the inferior head assists in downward, forward, and inward translation of the condyle during jaw opening.

It has two bellies superior and inferior with different functions:

The inferior muscle: It is very active during opening and advancing the jaw.

The superior muscle: Combines the elevators during closing movements, and it drags the condyle and disc medially. (McNamara 1973).

5.5. Infra and suprahyoid muscles

They fix the mandible with the hyoid bone and they include:

Digastrics (anterior, posterior), Geniohyoids, Mylohyoids and Stylohyoid.

When the hyoid is fixed because of sub hyoid muscles the digastrics and geniohyoid drag the mandible backwards during opening.

The sub hyoid and strap muscles cover the trachea and larynx and help to fix the hyoid.

6. Mandibular movement

Opening

Performed by lowering the mandible because of inferior lateral pterygoid contraction with the help of anterior digastrics and mylohyoids, at the same time the disc moves inferior of joint process and that cause backwards movement to the disc on the condyle.

Closing

Performed by the bilateral work of masticators, temporales and medial pterygoid with full harmonic action.

In TMJ the complex condyle-disc, return to the resting position by moving superiorly and backward along the articular tubercle. When the elevators contract the superior lateral pterygoid does also, that fixes the condyle-disc complex and rotates the disc anteriorly at the condyle.

Protrusion and Retrusion

The advancing action is achieved by the contraction of both inferior bellies of lateral pterygoid.

The retrograding is done by the tense part of temporales and suprahyoid muscles.

Laterusion

To the left: The contraction of right inferior lateral pterygoid, middle and inferior fibers of temporales.

To the right: Visa versa.

7. TMJ Movements

There are two kinds of movements:

Rotating movement between the disc and condyle in the inferior part of the joint.

The translatory cycle:

It starts from rest position of mandible. The disc-condyle complex moves anterior and inferior along the temporal tubercle, and the return period in which it moves superior and posterior towards rest position.

In the rest position, the disc middle area is kept between the condyle and the process.

The retrodiscal plate is relaxed during rest position, but when the complex moves anteriorly, the plate becomes active forcing the disc to move posteriorly at the condyle. This action prevents the disc to be dislocated anteriorly while the mouth is open.

During the anterior advancement period, the lateral pterygoid muscle is inactive.

In the returning period, the superior retrodiscal plate becomes inactive and the lateral pterygoid contracts so the disc rotates anteriorly at the condyle. Because of the lateral pterygoid position on the neck of the condyle, it has some control at the disc-condyle complex movements during returning period.

8. Occlusion

The majority of mandibular movements do not include teeth contacts, so the occlusion has no important effect on the joint function especially in the posterior rest position, and the condyle is fixed by the muscular tone.

Nevertheless, when the teeth are closed “biting”, the relation between the teeth of the upper and lower jaws is very important.

The minor changes between the central occlusion and the central relationship has little importance in TMJD, as Wilkinson suggested that the quantity and stability of occlusal contacts is more important than status of the central occlusion according to the central relation.

The mastication system has compensating factors to adapt with occlusion issues like interventions in work and balance side and the cross bite relations.

Joint stability

The articulating surfaces need continuous contact to keep the stability during the different conditions of the joint. Since these surfaces are not connected to each other, this relation is achieved by muscle action.

During rest, the stability is achieved by elevators muscle tone and equalized by gravity.

During transitional period the interference between the posterior temporal and inferior lateral pterygoid muscles keep the disc-condyle complex connected to the temporal tubercle.

The TMJ ligaments do not contribute to the stability but restrict the condyle posterior inferior movements.

The most important factor in keeping the stability is the disc location on the condyle which depends on auto centralization circumference beside anterior posterior movements of the disc.

The second factor is the intra joint pressure between the condyle and the temporal tubercle. When the teeth are in contact, this pressure will be high and the space between the condyle and the process is narrow so the thin part of the disc rotates between them. The reverse way during the rest position though the intra joint pressure is low and the space is large, the thick part of the disc rotates to fill the distance between the condyle and the process.

TMJ Adaptation

TMJ as other joints adapts with functional demands and has the capability of remodeling. Inside it there is cartilage covering of the condyle and the temporal tubercle. This cartilage has more capabilities than the ligaments; posterior attachment to adaptation but without enough vascularity and this capability differs from one person to another, depending on several factors such as load, general diseases and age.

The applied forces may become excessive or above the ability of remodeling, so many injuries or deformities may happen. These changes mostly happen in the lateral side of the joint.

1.9. Disorders Classification

It may not be logical to accept that all physicians agree to one classification of TMJs disorders. So many classification systems were suggested to reduce the problems and the arguments. Hansson and Hesse [61] put forward a diagnostic classification, which we use in the department of oral and maxillofacial surgery of the University-Hamburg. We considered this classification as a guide for our study.

- (1) Craniomandibular disorders, which have muscular origin.
- (2) Craniomandibular disorders resulting from Temporomandibular Joint disorders like:
 - 1- Shape deformity
 - 2- Anterior disc dislocation (Stage 1)
 - 3- Anterior disc dislocation (Stage 2)
 - 4- Hypermobility
 - 5- Osteoarthritis
 - 6- Acute anterior disc dislocation (Stage 3) without reposition
 - 7- Chronic anterior disc dislocation (Stage 3) without reposition
 - 8- Functional disorders resulting from developmental deformities (Hyperplasia, hyperplasia)
 - 9- Adhesions
 - 10- Functional disorders resulting from Condylar fractures.

We noticed that most of the previous injuries were usually associated with pains not only by examination (palpation) but also during the physiological

movement of mandible in its natural range. That may be resulted from inflammatory reactions in the area.

1.10. Radiography

Tomography

Sagittal tomographic studies from the outer lateral edge through the medial pole of the condyle, in both closed and open positions, are excellent for the detection of skeletal abnormalities. Coronal plane (anteroposterior) tomographic imaging of the TMJ can sometimes be helpful. In most cases, however high quality sagittal tomography is more than adequate to validate and classify osseous abnormalities.

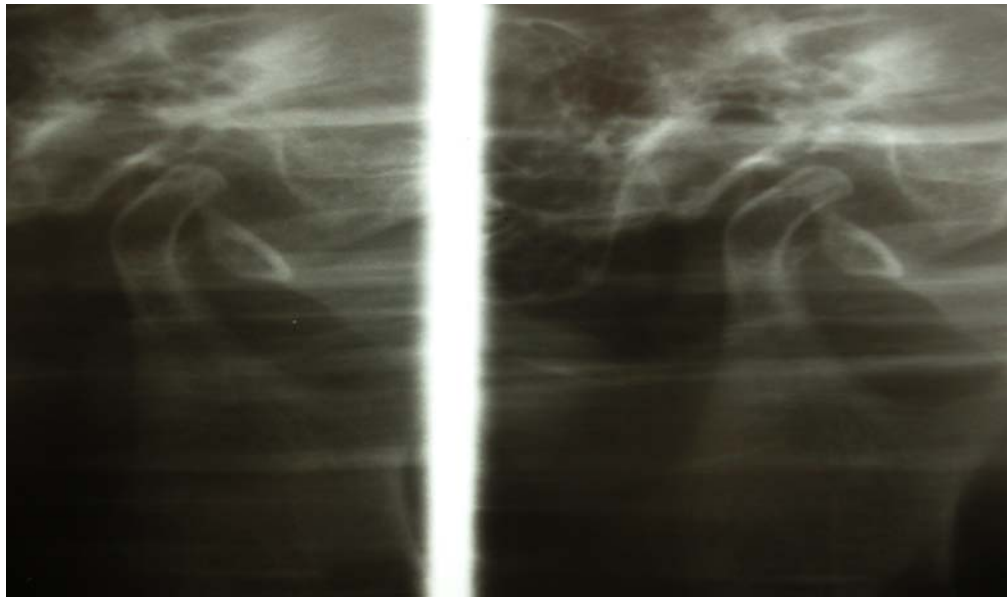
Sagittal homographic techniques in both closed and open positions are an accurate means of assessing the condyle-glenoid fossa relationship.

In general, the condyle-glenoid relationship has little predictive value relative to disc cartilage position.

On full opening, the condyle should translate forward to the medhorizontal portion of the distal eminence. This correlates with an opening interincisal measurement between 40 and 50 mm.

Hypermobility and reduced range of motion are not predictive of disk cartilage position. The findings are nonspecific.

By arthrosis, the adaptative changes (flattening of the articular contour, sclerosis and subarticular cystic change) often correlate the disk cartilage displacement.



right

closed

open



left

open

closed

Fig. 13 Tomography of the TMJ in a 27-year-old man with disc dislocation without reposition

Finally, tomography is extremely useful for initial treatment planning and longitudinal follow-up study, the thin-section high-resolution lateral tomography in closed and open positions has significant predictive value.

It has an excellent cost/benefit ratio for both initial and long-term follow-up examination. In other cases, we needed additional diagnostic documents such as (MRT or Arthrography).

Arthrography

This is achieved by injecting contrast medium into the upper space of the temporomandibular joint to see the discrepancy between the lower articular space and the upper space. In some cases, we resorted to injecting the iodous material in the two joint spaces, the upper and the lower one.

Arthrography provided information about the position and the form of the disk. It gave us an idea if there are any perforation or adhesions.

It also ensures diagnosis, which includes functional and non-functional information of the joint.

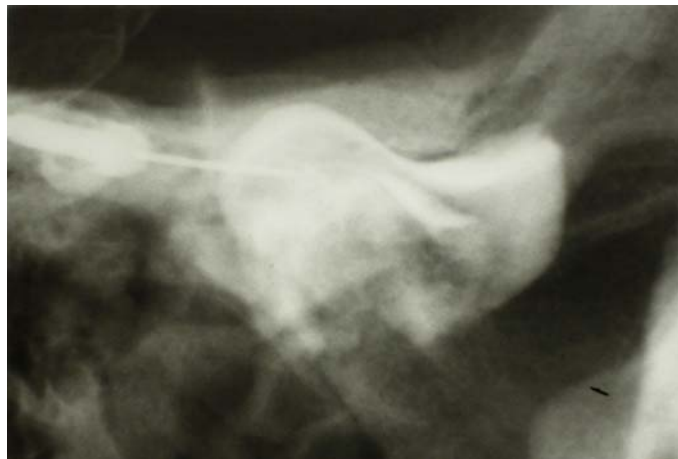


Fig. 14 Arthrography in 34-year-old woman
with disc perforation (left side)

The injection of contrast material into the joint's spaces was for some patients a painful and disturbing procedure; therefore, we resorted to less discomforting diagnostic imaging methods such as magnetic resonance imaging (MRI).

Magnetic Resonance Imaging

There are no significant biologic side effects of MRI, but there are precautions. Metallic clips, metallic foreign bodies, pacemakers, and some cardiovascular appliances can be effected and inadvertently displaced. TMJ joint prosthetic devices, dental fillings and braces are not affected by the magnetic field.

MRI studies should be obtained in multiple planes of imaging (sagittal and frontal) using variable pulse sequences to create selected T1 and T2 weighted images.

The studies should be further optimized by using a small field of view imaging coil. This enhances resolution of soft tissue and skeletal abnormalities.

The imaging via magnetic resonance essentially depends on hydrogen consistency of the tissue

The MRI signal pattern within the TMJ disk cartilage shows a low percentage of (H pos) protons; it is a black, low signal registration. Bright white signal patterns are usually indicative of inherent proteinaceous materials or water densities, such as edema patterns.

The knee fibrocartilage is comparable to the TMJ disk cartilage. Various signal patterns have been observed in the knee cartilage and the findings validated with arthroscopy and open surgery. The bright white signal pattern of knee cartilage has been graded from minimal involvement (grade1) to maximal involvement (grade 3). In general it is quite common to see an increase in signal pattern within the knee cartilage, but only when there is a break in counter of the fibrocartilage is it indicative of internal derangement or degeneration (grade 3).

In similar fashion, we observed a relative increase in signal pattern within the TMJ disk cartilage.

Before the availability of MRI studies of the TMJ, it was difficult to document joint effusions. In a study of Quentin N. Anderson 2000 it was found that joint effusion is quite common. They occurred in normal asymptomatic patients 15%

to 20% of the time and in approximately 75% of patients with internal derangement.

Quentin found that the presence or absence of a joint effusion has little predictive value relative to classifying TMJ disorders. The increase in bone marrow signal pattern (bright water density) has no relationship to avascular necrosis; these findings are similar to those seen in transient osteoporosis, stress fractures, osteomyelitis, and non-specific marrow infiltration.

The MRIs ensured a clear view of the disk and the soft tissue without injecting any shady material.

The tissues and the structures that include air, such as the maxillary sinus, have a low level of hydrogen concentration, so they appear dark on the imaging. Similarly, the cortical bone contains less hydrogen and appears dark or black, whereas the fatty regions appear light grey or white because of the existence of the high hydrogen concentration.

The appearance of the tissue in the MRI.

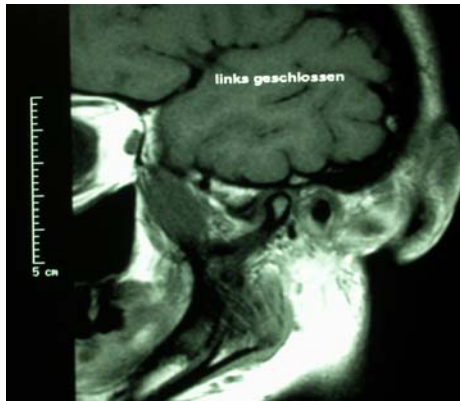
- White: lipid, bone-marrow, brain

- Grey: muscles, body liquid, intestines

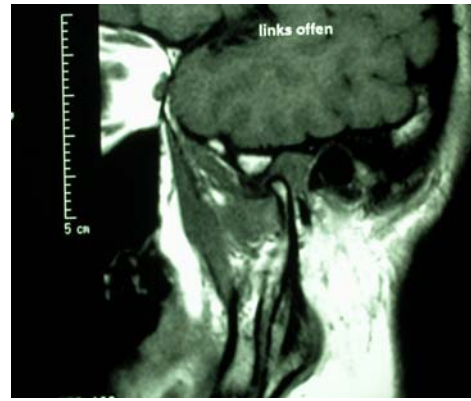
- Black: air, cortical bone

Finally, we found that MRIs were an excellent means of evaluating soft tissue abnormalities of TMJ and cost-effective for initial treatment planning and long-term follow up.

In our study, the MRIs were made in the sagittal and frontal sections, to show the disk displacement, ruptures, and inflammatory changes and the articular abnormality in the two levels, sagittal and frontal.

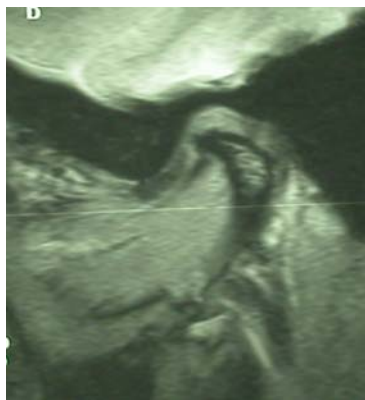


left closed

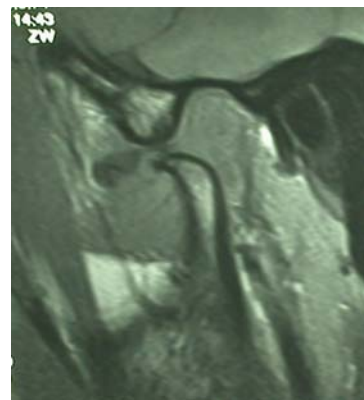


left open

Fig. 14 MRI of TMJ in 24-year-old women with disc dislocation without reposition left side



left closed



left open

Fig. 15 MRI of TMJ in 38-year-old woman with disc dislocation with reposition left side

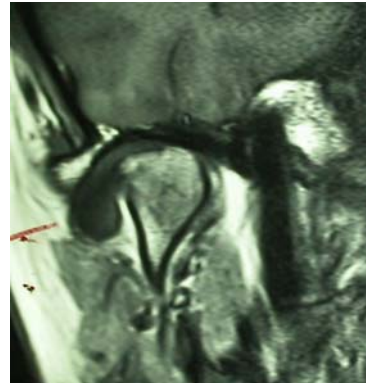
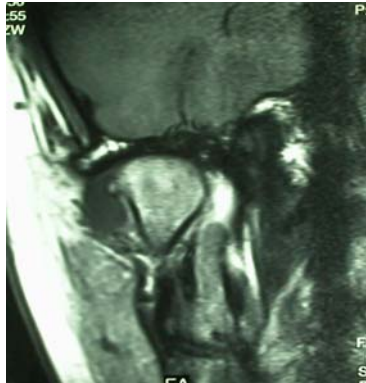


Fig. 16 MRI of the TMJ (coronal section) in the same patient (Fig. 15) with anterolateral disc dislocation with reposition right side.

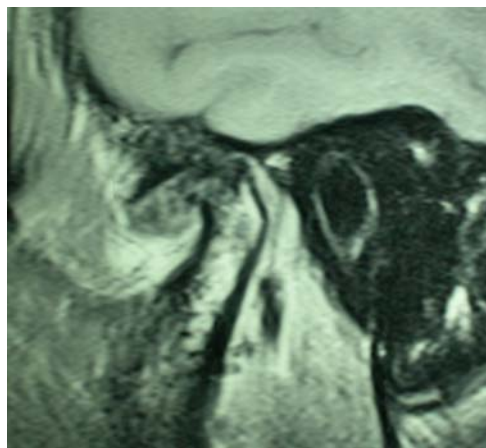


Fig. 16 MRI of the TMJ in the 52-year-old women with progressive osteoarthritis left side.

1.11. Occlusal splint

A movable device composed of hard acrylic material separates the two dental arches and fixed on one arch only.

It is considered a reverse biomechanics way to treat pain and TMJ dysfunction Boero [12], in patients with myofascial pain, the presumed mechanism of action of an intraoral splint is via the relaxation of muscle, either by a change in the muscle itself or by a change in the patient's function-parafunction when the teeth come together.

Clarck [27] stated that the splint therapy decreases the symptoms of myalgia.

1995 Abu baker stated that the splint therapy is an effective therapy in pain management of those patients with intracapsular temporomandibular disorders including treatment of disc displacements and temporomandibular joint (TMJ) arthritis.

Zamburlini [142] and Le Bell [83], the recapturing of the disc by use of a splint does not guarantee its correct position permanently.

CohenSG 1994, mechanically altering the position of the mandible can result in the condylar head being held in a more inferior, anterior position will mechanically persuade the disk to establish itself atop the condylar head in a more favorable position.

Chung SC [25] when the clinician is faced with a patient with closed lock of the temporomandibular joint tries to manipulate the lower jaw and distract the condyle from the glenoid fossa to reduce the disk mechanically. If manipulation of the jaw is successful in reducing the disk, then splint therapy is indicated to continue to unload the joint and decrease inflammation while increasing range of motion.

De Bont [36], current controversy does exist concerning use of splint therapy in preventing the progression of arthritis in the temporomandibular joint.

Fonseca R 2000 [42], splints used in the treatment of arthritis of the temporomandibular joint are usually viewed as one particular mode of treatment

in a multitherapy-based overall treatment plan.

Fonseca 2000 [42] the most commonly used splint in the treatment of myofacial pain is known as the stabilization splint. It is a full-coverage maxillary or mandibular splint incorporating even posterior contact at the point of maximum closure.

Okeson [95], various types of repositioning appliances have been used to alter condylar position at occlusal contact positions in an attempt to recapture a displaced disc.

Fonseca 2000 [42], repositioning appliances include the maxillary anterior repositioning appliances, the ligated anterior repositioning splint as well as various types of mandibular orthopedic appliances.

Boero [12], the stabilization splint is constructed in relation to the patient's centric occlusion or relation position.

Most often, the splint is made from a hard acrylic plastic resin.

Hawley bite plane splint is another type of splints, which has been used to reduce muscle activity and treat patients with myofacial pain.

Orenstein ES 1993 and Gelb ML 1991 [42], there are some repositioning appliances are worn over the lower teeth and have deeper indices, which guide the mandible into an anterior position. Variations of these mandibular orthopedic appliances are called Friedman, Gelb, and TMJ Blank appliances.

Fonseca [42], the most commonly used splints are:

1. Stabilization splint
2. Repositioning splint
3. Mandibular orthopedic repositioning appliance or Gelb splint
4. Pivot splint
5. Soft splint
6. Bite plane splint

2. Material and Methods

2.1. Patients

Between 2001 - 2003, 180 patients visited the department of Oral and Maxillofacial Surgery -University Hamburg; suffering from TMJD and craniofacial pain.

All patients were selected to have splint therapy as an essential condition of the therapy plan. They were divided into 3 groups according to the occlusal splint thickness, which were used during splint therapy:

The first group: the thickness of the occlusal splint was 1.5 mm

The second group: the thickness of the occlusal splint was 2.5 mm

The third group: the thickness of the occlusal splint was 3.5 mm

The patients were chosen haphazardly, with different sex, age, and diagnoses, to obtain prospective results about the patient adherence to apply the occlusal splint for long time and for all patients. By the first visit, the patient was examined and X Rays were performed to reach the correct diagnoses, then we obtained the impression of the two jaws with the face bow records to form the individual splint with help of Artex articulator. The medicine and physiotherapy were prescribed to patients who needed it, according to our diagnoses and treatment scheme.

By the second visit, we let the patient wear the splint. All patients were recalled for periodical visits after 2 weeks, 4 weeks, 12 weeks, 24 weeks. Through these periodic visits we could observe the condition progress, and obtain accurate information about patient abiding to wearing the occlusal splint during the past period. On drawing a comparison between the progress of symptoms and the improvement of conditions and success of treatment; linking that comparison to the thickness of the applied splints, extent of patient's observance thereof based upon questioning the patients as to extent of using the splint after stressing to them the importance.

2.2. Diagnosis scheme

The general treatment of patients with temporomandibular disorders depends firstly on the correct diagnosis. Here we should distinguish between the pain that result from the temporomandibular joint disorders, which are called temporomandibular joint dysfunctions (TMJD), and the pain that result from the oral-facial pain (OFP) that have non-masticator origin.

The diagnosis of the TMJD is not as complex as in the diagnosis of the oral-facial pains, which may last months. Some patients suffer from pains resulting from TMD and OFP at the same time, which makes the investigation of the real reasons and then the treatment very difficult.

The medical history was the most important diagnostic key, therefore, we asked our patients about their personal information and their complaints in a comfortable environments. Additionally we referred the patients to another medical competence to exclude other diagnoses.

2.2.1. Components of an evaluation for patients with orofacial pain disorder

History of presenting illness

Past medical history

Personal history

Physical examination

Diagnostic studies

Consultation

2.2.2. History of the presenting illness:

Chief complaint and associated symptoms

Pain character

Pain severity

Temporal characteristics of the pain

Precipitating, aggravating, and alleviating factors

Onset date and events

Preexisting conditions

History of pain progression or persistence

Past and present medications

Past and present surgeries and other treatments

What led to referral

2.2.3. Medical history

General health

Family history

Allergies

Past and present medication

Past surgery

Previous hospitalizations

Past or present illness such as diabetes, heart disease, cancer

Last examination by the physician and dentist

Infectious diseases

Bleeding disorder

2.2.4. Component of personal history

Family

Childhood

Education

Occupational

Social

Relationships

Health

2.2.5. Physical examination for temporomandibular disorder and orofacial pain

General appearance

Mental status

Head and neck inspection

Cranial nerve function

Stomatognathic function

Muscle and joint palpation

Occlusal stability and function

Muscle strength and postural relationship

2.2.6. Diagnostic studies

Nerve blocks

- Peripheral nerve block

- Local infiltration

- Myofascial trigger point injection

Radiographs:

- TMJ mouth opened and closed

- TMJ arthrogram

- Magnet resonance imaging

2.2.7. Physical examinations

Physical examination for temporomandibular disorder and orofacial pain varies, depending on the location of the pain and tentative impression or diagnosis. A physical examination may include inspection, palpation, percussion, auscultation, smell, and measurements to ascertain whether an abnormality or dysfunction that is related to the chief complaint is present.

Inspection can reveal considerable information about the patient to alert clinician.

Slouching posture can point to depression; postural rigidity or clenching behavior can show excess muscle tension in the neck, shoulders, or jaws and may be associated with myofacial pain.

Palpation is the process of using touch to examine the body for signs of abnormalities. It can include finger palpation of the muscles for myofacial trigger points, the skin for hyperesthesia in causalgia, cold hands in migraine, lymph nodes for lymph adenopathy, joints for swelling and tenderness of arthritis, and the rest of the head, face, neck, or body for a variety of possible conditions.

Percussion of a part of the body can also be used in an attempt to detect clinical signs. For example, relative densities of parts of the body can be ascertained by listening to the sound produced by striking a finger against the opposite hand while it lies flat against the body part.

Auscultation is the act of listening to body sounds through a stethoscope. Such crepitus in the joints, vertebral, and basis vertebral insufficiency.

A general appearance assessment includes factors such as ambulation, general malaise, postural imbalance, and general motor function.

A mental status examination reveals the patient's state of awareness, general appearance, behavior, mood, affect, language, function, nonverbal function, and memory.

General examination of the face, neck, head, and shoulders

Tenderness of muscles is an essential criterion for diagnosing masticatory muscle disorders such as myofacial pain or myositis. In addition, tenderness on palpation of the TMJs strongly suggests the presence of synovitis or capsulitis of the joint.

The diagnostic criteria for myofacial pain primarily in our study involved:

- 1- Localized tenderness to palpation at points in firm bands or skeletal muscle, tendons, or ligaments, often termed “trigger point”.
- 2- Pain complaints that follow consistent patterns of referral from trigger points
- 3- Reproducible alteration or replication of the pain with specific palpation the trigger point.

We began by detecting any obvious features, such as the decrease in the ramus dimension, hyperplasia of the masticatory muscle (a mark to parafunctional activity).

We palpated the masticator muscles gently to reveal if there were any excessive sensitive area (trigger points), which may cause neurological disorders or secondary central stimulations that affect the facial muscle.

We had also followed the procedure that Tanaka advised to examine the head, the face, the neck and the shoulders:

- (1) We should examine and evaluate the muscles in their rest position. It should be in their complete length. We should also examine their origin, their fulcrum and belly.
- (2) We should examine the muscles at rest, contraction and relax positions.
- (3) We should examine the muscles of the two sides to compare the difference in flexibility, size, and reaction to palpation.
- (4) We should test the muscles horizontally and parallel to their junctions.

We know that the examination of trigger points in the muscles include a dynamical reaction by the patient. When the pressure increases, the patient may feel pain, and when we press a trigger point, the patient feels pain transversely.

We palpated the surfaces of the facial muscles by using the middle finger. We applied constant gentle pressure with circular movement for 10 seconds. Then we asked the patient if he felled pain or disturbance.

Temporal muscle:

A palpation was performed at the examination (testing) of the posterior, middle and anterior parts of the temporal muscles. In addition, the muscle is put in

partly contraction position by asking the patient to enter one or two finger's vertically between the incisors.

The temporal muscle insert was palpated on the coronoid process. We could achieve it intraoral by using one finger on the upper part of the interior surface of the ramus whereas the other hand was put at the same area outside the mouth.

Masseter muscle:

The masseter muscle was palpated on the origin of the zygomatic bone, and the belly at the middle of the ramus as well as the insert on the lower mandible angle.

Lateral and medial pterygoid muscle:

It was difficult to palpate the medial pterygoid muscle directly because of its anatomical position. We tried to palpate the body of the medial pterygoid muscle by pressing it tenderly on the medial face of the ramus of mandible, but this stimulated the vomiting reflex by patients.

A functional stimulation was performed to the anterior and superior pterygoid muscles (lateral) to evaluate their function by lateral movement.

Suprahyoid Muscles:

These muscles were examined by pressing on the hyoid area (inframandibular) while the head was tilt backwards by closing position.

The mylohyoid muscle was palpated by pressing it from intraoral with one finger and another finger supporting it from extraorally.

Sternocleidomastoids muscle:

This muscle was palpated by the forefinger along the muscle.

We asked the patient to tilt his head towards the shoulder and to circle it towards the opposite side, which enabled us to examine the contraction of this muscle.

Trapezius Muscles:

The upper part of the trapezius muscles based along the skull base.

We could easily reach this muscle by pressing it with the forefinger on its length extension.

Examination of the temporomandibular joint

Joint movements

Maximum opening:

Patients were asked to open as wide as possible and we measured the distance from incisal surface to incisal surface of maxillary and mandibular central incisors at the midline.

Positive result if 39 mm or less.

Passive stretch opening: Gentle stretching by us beyond voluntary maximum opening and measured identical to maximum opening

Positive result if 41mm or less.

Restriction:

Positive result if maximum opening is less than 40 mm

S deviation on opening:

An S curve deviation on opening or closing was positive result if more than 2 mm from midline.

Lateral deviation on opening:

A lateral deviation at full opening was positive result if more than 2 mm from midline

Protrusive Pain:

Any Pain but not pressure or tightness, during or at maximum protrusion was positive result; teeth were slightly out of contact at end of range of motion.

Protrusive limitation:

We measured the distance between labial surfaces of the maxillary incisors at the maxillary midline when in centric occlusion and again at maximum voluntary protrusion; result was positive if the difference between the two values is less than 7mm.

Right and left laterotrusion:

Pain and limitation: we marked the point on the mandibular incisors that matches the maxillary midline and measured the difference between this midline and the mandibular point after maximum laterotrusion; result was positive if less than (7mm).

Clinically can or is locked open:

Voluntary or involuntary forward dislocation of the condylar head out of the glenoid fossa combined with fixation in that position.

Clinically can or is blocked closed: Voluntary or involuntary blocking of translation of the right and/or left condyle that was of short or permanent duration (fixation) as determined by manual palpation.

Joint sounds

The articular sounds were detected with the stethoscope during all mandible movements. In addition, the tip of the finger was put at the same points of the two joints to detect in which opening stage sounds happened.

The sound that was determined was the clicking.

Initial clicking when it happens at the early opening stage 0- 15 mm

Intermedial clicking: when it happens at the middle opening 16 - 30 mm.

Terminal clicking: when it happens at the final opening 30 - 45 mm.

If we noticed that there was an excessive opening movement, we made a general examination of the patient, especially the joints (fingers, elbow, and knee), if we found an excessive movement in two joints or more, we considered the case as a systemic joint disease.

Palpation of the temporomandibular joint

The temporomandibular joint and the facial muscles were palpated by standing in front of the patient to identify any eyelid, face response during the test.

Pain on opening had positive result if any pain but not pressure or tightness, occurs with stretch or with maximum opening

We classified the reaction of the patients into 4 grades:

(1)There is no pain or pathological reaction: grade 0

(2) There is a mild pain: grade 1

(3) There is moderate pain or eyelid responds: grade 2

(4) There is a strong pain with a clear respond. (For example, the patient draws his head during the palpation or prevents the doctor to do it at the ear area): grade 3.

During the slow mouth opening, we could palpate the lateral side of the condyle and any pain response or quick influence was classified according to the previous category.

We paid special attention if there were any joint swellings or if there was an increase in the temperature in the joint area, which refers to inflammation or infection that may change the treatment.

Mandibular provocation examination

These tests are useful to determine the complaint's position and its relation to muscle.

This examination depends on the principle, which says that the lesions inside the muscle are more painful when the muscle contracts, but when the muscle is in the rest position, these lesions are less painful. The muscular palpation may cause pain at the glands regions, which mislead the doctor and cause incorrect diagnosis.

The test is made with giving the patient enough time to make the greater resistance for 20 seconds, when pain appeared we stopped the examination.

(1) Opening against resistance:

We supported the patient's head with one hand and the other hand was put under the patient's chin with applying force against the mandible movement direction during the opening of the mouth. We registered all reaction as well as pain region (area).

(2) The protruding against resistance:

It is the test of the lower belly of the lateral pterygoid muscle. We asked the patient to protrude his mandible while applying force against his movement.

(3) The closing against resistance:

We supported the patient's head with one hand and asked him to close his mouth trying to resist the closing movement by the other hand by putting two fingers on the incisors area to test the elevator muscles of the lower jaw.

Intraoral evaluation and occlusal analysis

Intraoral inspection

The intraoral Inspection should be part of the temporomandibular joint disorders tests. It is necessary to make an accurate examination of the teeth to exclude dental pain reason, because the dental pain is a dominant pain state inside and around the mouth and it often imitates pain symptoms of other injuries.

All the teeth were tested to determine if there were caries, injured restoration, and teeth mobility.

We made X-Rays to detect any pathologic apical reactions.

The soft tissues test included inspection and palpation of the oral-mucous, the lips, tongue, hard palate, soft palate, and the larynx.

We detected any change in the soft tissue color or in its structure, and lesions or inflammatory reactions in the vestibular mucous.

Occlusal analysis:

Examining the dentition and occlusion is an important part of the physical examination of temporomandibular disorders (TMD) or orofacial pain patient.

It may provide useful information about bruxism or other oral habits and their possible effects on the dentition, periodontium, or other oral structures.

Such an examination can also reveal whether progressive changes in occlusal relationships have occurred, (midline shift, anterior open bite, unilateral posterior open bite, etc.) that may indicate the presence of such conditions as unilateral condylar hyperplasia, rheumatoid arthritis, or neoplasm.

Noting the number of missing teeth, particularly loss of posterior occlusal support, is also important since this situation may predispose the TMJs to degenerative joint disease (osteoarthrose), especially in the presence of bruxism. We began our occlusal evaluation by determining if there was malocclusion according to the Angle classification Class I, Class II, Class III.

The bite: open bite, deep bite, and normal bite.

These classifications were important because class 1 with a deep bite may refer to the retraction of the mandible with a deep bite and decreasing in the vertical dimension and a large rest distance.

On the other hand: the skeletal open bite is often associated with anterior open bite with increasing the occlusal vertical dimension and with small rest distance. This information was important to know if any long-time dental treatment is necessary.

We also tried to estimate the occlusal stability factor by some patient by asking them to close there mouth and knock there teeth together slowly for many times with intercuspidal interference position whereas we put the stethoscope on the zygomatic bone to determine how stabile the occlusion was.

In addition, we tried to identify the bilateral symptoms of the posterior and anterior dental contact in the maximal intercuspidal occlusion by using articular between the teeth surfaces and identify those points. The abnormal contact on one side may be produced from the excessive activity of the elevator muscles in this side, which leads to the muscular contraction. We investigated if there were excessive abrasions on the teeth surfaces, which refer to parafunctional activity. We also registered any other areas that referred to the decreasing in the posterior dental support.

2.3. Treatment Scheme

2.3.1. Pharmaco-therapy

The temporomandibular articulation is essentially dependent on the occlusal splint and physical exercises as treatment. Therefore, the pharmaco-therapy had a limited meaning in our study.

Many factors were considered before we prescribed the medicine. They are:

1-Body size and its composition

2-Patient age:

By old patients, the ability of the body to absorb, metabolize and excrete the medicine will decrease. It was considered that the medicine has strong side effects by those patients.

3-Pregnancy and nursing:

We tried not to prescribe any medicine to pregnant women because of the side effects, which may injure the fetus. We did not prescribe any medicine to pregnant women without asking the gynecologist. The same was followed for nutrix.

4-The medical condition:

The non-steroidal antiinflammatory drugs (NSAIDs) may affect the renal function. Therefore, we paid attention by patients with renal disorders.

5-Liver function disturbance leads to decreased metabolism and causes toxic reaction to the patient. In addition, liver diseases affect the using of many neurologic medicines.

6-Allergy:

We detected every medical history of allergic or pulmonary disorder such as asthma before prescribing the medicine to avoid any allergic reaction. We preferred to choose the oral application.

7-Drug abuse:

We were careful by dealing with patients who took medicine for long-time without prescription which may have lead to drug abuse as well as decreasing the remedial effects or increase its toxic effects.

8-Tolerance:

The body response to drugs decreases, if the patient took these drugs for long time. By reaching the tolerance phase, the medicine dose should be increased.

9-Drug interactions:

Some drugs may have many effects, such as aspirin. It is an analgesic, anti-inflammatory and anti-coagulatory factor.

Generally, in our study, the essential drugs that we used in temporomandibular joint disorder were NSAIDs (Diclofenac, Ibuprofen) and muscle relaxants (Tetrazepam).

NSAIDs:

(Diclofenac) 50 mg x 3

(Ibuprofen) 400 x 4

(Only when the patient had continuous pain on the affected side)

Muscle relaxation:

(Tetrazepam) 25 mg x 2

(Only when the patient had painful muscle contraction and trigger points)

It has terminal effect, which decrease the muscle contraction. It is so effective in short treatment protocol for muscle spasms and has side effects such as dizziness, headache and somnolence.

2.3.2. Physical therapy

Muscle Disorder Treatment:

The muscle pain is widespread. It is described as deep, continued, dull ache or tightness. Patient are generally depressed because of the pain. These cause isolation and make the patient decrease his activity. The pain area is different from pain origin.

The muscle pain is divided into two kinds, acute and chronic. The chronic pain last for more than three months according to the International Association Study Pain (IASP). This association classified the acute pain into two categories:

1-Splinting pain:

The splinting of the muscle is a prophylactic reflex, which includes central nervous mechanism that leads to muscle blocking or muscle tightening.

The muscle has a local contraction and pain as well as movement limitation. The patient is nervous and suffers from anxiety because of the movement limitation and the pain. At the rest position, the pain is minimal but increases with stimulation.

The management:

The treatment protocol depended on the fact that the preventive muscle splinting disappears with alleviation of the reason. The treatment was as follows:

- (1) Sedative treatment with damp heat.
- (2) Short- time treatment course of Tetrazepam.
- (3) NSAIDs (if the complaint has inflammatory origin).
- (4) Occlusal splint to prevent repeated trauma on the joint and muscles, if the pain was in the head and neck subsequent to nocturnal occlusal activity (bruxism).

2-Myospasm pain:

The muscle spasm is acute disturbance in one or several muscles. The spasm manifests with involuntary sudden contraction leading to pain and movement limitation. The spasm results from acute overuse such as long-time mouth opening during dental treatment. The myospasm pain of the masticatory muscles ranges from light pain to more severe constant pain, when the muscle contracts. The patient may have movement limitation with midline deviation to the affected side (the same side) without any hindrance of the mandible protrusion.

That was considered as a differential diagnostic mark from the acute anterior disc dislocation without reposition, which causes midline deviation to the opposite side.

The management:

- 1- We advised the patient to reduce the mandible movement for a period, which helped him to minder the pain severity.
- 2- Moist/Dry heat-superficial: Changes in tissue temperature resulting from superficial heating depend on the intensity of the heat applied.

2.3.3. The splint therapy

Specific splint types that are used in the treatment of TMD patients include the stabilization splint and the anterior repositioning splint.

Although there are many kinds of appliances, all of them fulfill the same tasks:

- 1- Allow free mandibular movement
- 2- Prevent occlusal interferences.
- 3- Decrease the muscular activity evidenced by EMG studies
- 4- Do not allow full flexion of closing muscles
- 5- Provides stable dental occlusion
- 6- Aid in cognitive awareness
- 7- Possible effect on bruxism
- 8- Placebo effect

In this study, the splint was designed to be nice and comfortable. Two types were used depending on the diagnosis:

- 1- Stabilization splint.
- 2- Repositioning splint.

The place (upper or lower jaw splint) depended on several factors like diagnosis, occlusion and cosmetic factors. The thickness, which is the main subject of our study, was:

1.5 mm for the patients Group1

2.5 mm for the patients Group 2

3.5 mm for the patients Group 3

Moreover, we completed commitments from the patients to use the device in its right time and places and to give us accurate information about his abiding with the splint therapy; because the information's we get from the patient will be the main source of our data concerning the effectiveness of treatment.

Stabilization Splint

It is the most commonly used splint in the treatment of myofacial pain. It is a full-coverage maxillary or mandibular splint incorporating even posterior contact at the point of maximum closure.

The splint usually has anterior disocclusion in protrusive as well as canine guidance or group function in lateral excursion.

It is constructed in relation to the patient's centric occlusion or relation position.

Indications:

1. Disk deformation
2. Anterior disk dislocation stage 1
3. Anterior disk dislocation stage 2
4. Mandibular hypermobility
5. Chronic anterior disc displacement without reposition stage 3
6. Adhesions
7. Joint traumatic injuries.

Anterior Repositioning Splint

This device has been made with occlusal surface to achieve the attachment with the opposite teeth to drag the mandible to an anterior location.

In addition, the maxilla has not been chosen for fixation because it has many cosmetic problems as well as interference with speech.

Indications:

- 1- The acute anterior disc dislocation grade 3 (irreversible) which is

continuously remolded until achieving the central essential occlusion and maintaining it for 6 months.

2- Post surgical period: can help maintain a surgically reduced disc.

In general, the main indication for anterior remolding appliances are the anterior irreversible dislocation if it is the cause of pain. The pain will subside because it prevents the condyle from attaching the posterior ligament that is full of blood and nerve supply and it can be reduced by stopping the ligaments from stretching.

We considered the subsistence of pain and clicking/crepitation as a sign of treatment success though the success ratio will be very low .

If we considered the subsistence of pain only as a sign of treatment success the success ratio will be very high.

The duration of treatment was 3-6 months according to the patient's behavioral and histological response with the degree of injuries and healing process.

After 3 months and in the case of no symptoms we transform the reposition splint to a stabilization one to let the mandible return to its normal position.

If the painful symptoms did not returned after this procedure, we referred patients to a dentist to make the irreversible dental treatment as apart from long time treatment of anterior mandible fixation.

If the symptoms reappeared and the cure in palliative therapy has failed, we referred patients to the surgical management.

2.3.4. Temporomandibular joint disorders: Diagnosis and treatment scheme

Disc deformation

- Symptoms:
1. Clicking in the same point during mouth opening and closing. This is the position from the rotational movement to the translatory movement.
 2. Pain if there is an inflammatory reaction

Etiology: Excessive strain of the joint → tissue reaction and edema
→ components anatomical structural degenerative
changes → clicking

Treatment:

1. NSAIDs if there were any inflammatory reactions.
2. Stabilization splint to distribute the masticatory forces equally in all the occlusion surfaces for 24 hours and for six months.
3. Occlusal selective grinding to the occlusal interference areas during the transport movement from the central relation to the central occlusion after six months from the treatment by the plate.
4. Reconstruction of the unsupported occlusal areas and correct the vertical dimension through the prostheses in the case of teeth loss.

Anterior disc dislocation (stage1)

Symptoms:

1. Clicking in the first phase of mouth opening.
2. Clicking in the first phase of mouth closing.
3. Clicking during the lateral movement of the mandible towards the opposite side.
4. Pain may happen in the affected joint.

Etiology:

1. Trauma by the young patients ⇒ shape and size asymmetry due to asymmetrical growth →

instability in the joint during mandible movements.

2. Occlusal disturbance → lateral obligatory movement of the mandible ⇒ abnormal occlusal loading of the joint.
3. Congenital reasons that manifest as inconsistency between the condyle size and the fossa size ⇒ increasing of the joint spaces, which leads to instability inside the articulation.

Treatment:

1. NSAIDs if there was inflammatory reaction.
2. Stabilization splint for six months to shorten the rotational movement of the condyle.
3. Orthodontic treatment, especially by young patients with selective grinding of occlusal interference areas during the lateral movements.
4. Restoration and prostheses by the old patients if they refuse the orthodontic treatment.

Anterior disc dislocation (stage 2)

Symptoms:

1. Pain in the affected joint.
2. Clicking in the middle of the mouth opening movement as well as through the closing route in the different point.

Treatment:

1. NSAIDs if there was inflammatory reaction
2. Repositioning splint:
 - A. Decrease the edema that result from the additional loading during the repeated movement of the disc, the edema leads to pain in the posterior ligaments of the disk.
 - B. Protrude the mandible to avoid the clicking that results from the disk replacement as the condyle return to its position from the translatory movement to the rotational movement.
3. Stabilization splint: in case that the treatment by the repositioning splint has no success.

Hypermobility

Symptoms:

1. Clicking at the end of mouth opening by slipping condyle-disc outside the temporal process.
2. Mandible deviation toward the unaffected side during mouth opening after the clicking.

Etiology:

It was considered: the distension of disc posterior ligaments as well as stretching in the articular capsule.

Treatment:

1. Stabilization splint: It improves the functional symmetry and it may help the patient to learn how

to limit his mandible movement and supports the muscle function.

2. Physical treatment: It helps to learn opening movements without any exaggeration and to reduce the slipping movements of the condyle, which result from the harmony disturbance of the muscle activity.

Osteoarthritis

Symptoms:

1. Deflection of the mandible during mouth opening.
2. Crepitation during mandible movement.
3. Osteo degenerative deformities of bone surfaces
4. The superior surface of condyle becomes flat.
5. Superior space of the joint becomes narrow.

Etiology:

Excessive exertion as well as chronic dysfunctions of the joint without treatment.

Treatment:

Increase the vertical dimension by using the stabilization splint for at least six months.

The aim of the treatment is to reduce the overexertion of the affected joint and achieve symmetrical activity for the muscle, and eliminate the nocturnal parafunctions and bruxism.

Acute disc dislocation without reposition (stage 3)

Symptoms:

1. Excessive sudden movement limitation of the mandible.
2. Mandible deviation towards the affected side by mouth opening.
3. The lateral movement towards the unaffected side is painful.
4. Mandible deviation to the effected side by protrusion.
5. Pain on the affected side.

Treatment:

1. NSAIDs
2. Manuel reposition of the mandible.
3. Repositioning splint with several occlusal adjustment of it until get to central occlusion, then we can consider it as a stabilization plate and then applied it for another six months.

Chronic disc dislocation without reposition (stage 3)

Symptoms

The same in the acute disc dislocation but for long time, without pain.

Treatment:

1. Stabilization splint for a long time, for one year or more than one year, because the disk articular is excessive injured and it needs long rehabilitation.

2. Physical treatment: to achieve symmetrical muscle function parallel to splint therapy.
3. In the case of constant pain without improvement
→ surgical treatment.

Developmental disorders

Hypo or hyperplasia of the condyle

Treatment:

1. Stabilization splint
2. reconstructive or orthodontic treatment to get a symmetrical occlusion.
3. Physical treatment for a long time

Adhesions

Symptoms:

1. Movement limitation of the mandible
2. The mandible deviates towards the affected side by mouth opening.
3. There is no pain.
4. The adhesion may be osteo adhesion as well as fibrous adhesion that cannot be recognized by X-Ray images.

Treatment:

1. Physical treatment with movement exercise for the mandible.

2. In the case of the success of the physical treatment, we used a stabilization splint with several occlusal adjustments.
3. Occlusal reconstruction with prosthetic or orthodontic treatment.
4. If the previous treatment was not successful, we must resort to surgical correction.

Traumatic disorders

Condylar or mandibular fractures.

Symptoms:

1. The deviation of the mandible towards the affected side.
2. There is no excessive limitation of the mandible movement.

Treatment:

1. Stabilization splint for two months to get a symmetrical muscle activity.
2. Occlusal selektive adjustment.
3. Increasing of the vertical dimension via occlusal reconstruction (bridges- prostheses).
4. Physical treatment

9.4. Artex articulator

Ahlers [2] stated, it is an occlusal device which simulates the masticatory function, partially modulated with calibration possibility:

Condyle passage tilts 15 - +60 degree

Benet's angle 0----- 20 degree

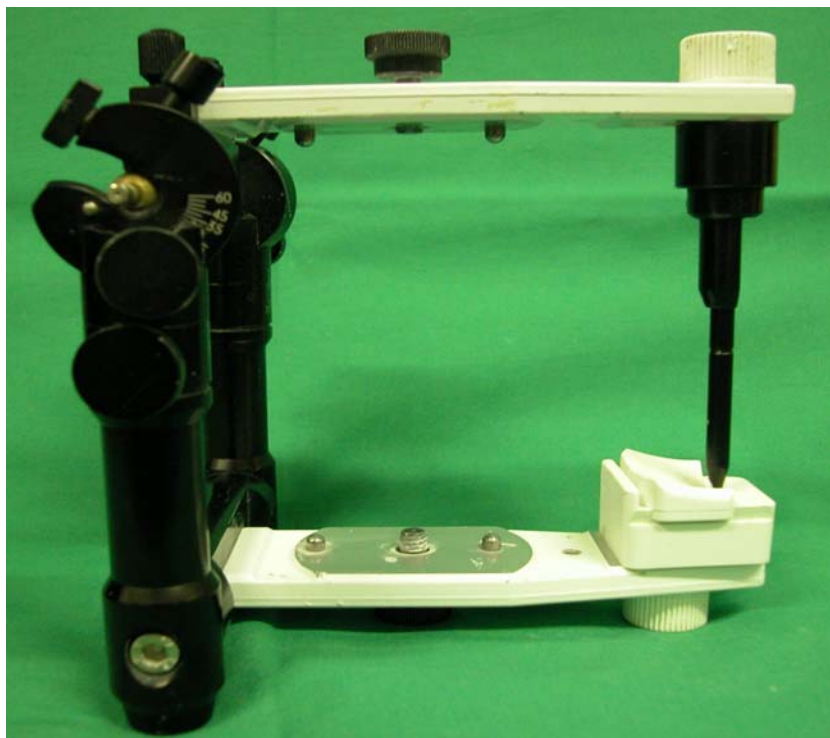


Fig.17 Artex articulator

Bilateral condylar conductor controls its movements. It can simulate the mandible in protrusive movements that is common in dental practice to achieve an occlusal simulation to check the validity of the occlusal splint.

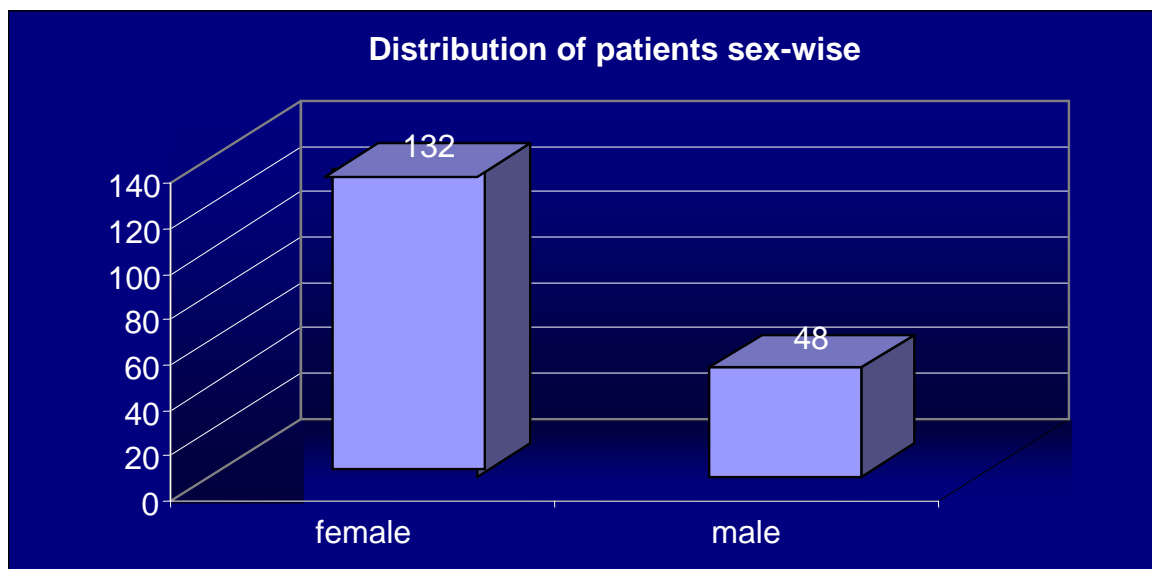
The condylar guidance of Artex articulator is blocked in the vertical direction, so the retrusive movements are controlled and linked towards the protrusive movement of the mandible.

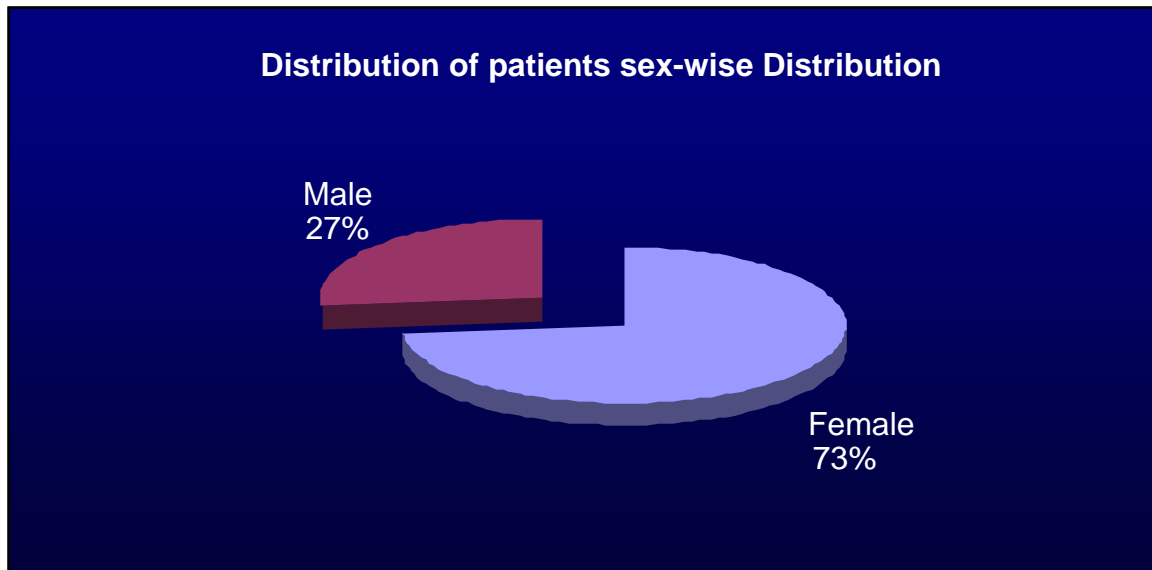
Similarly, the condylar giddiness prevents any elevation of the condyle that cannot be overlapped in dental practice but it makes the occlusal splint construction in the labor much easier.

3. Statistical Evaluation

3.1. Distribution of patients sex-wise

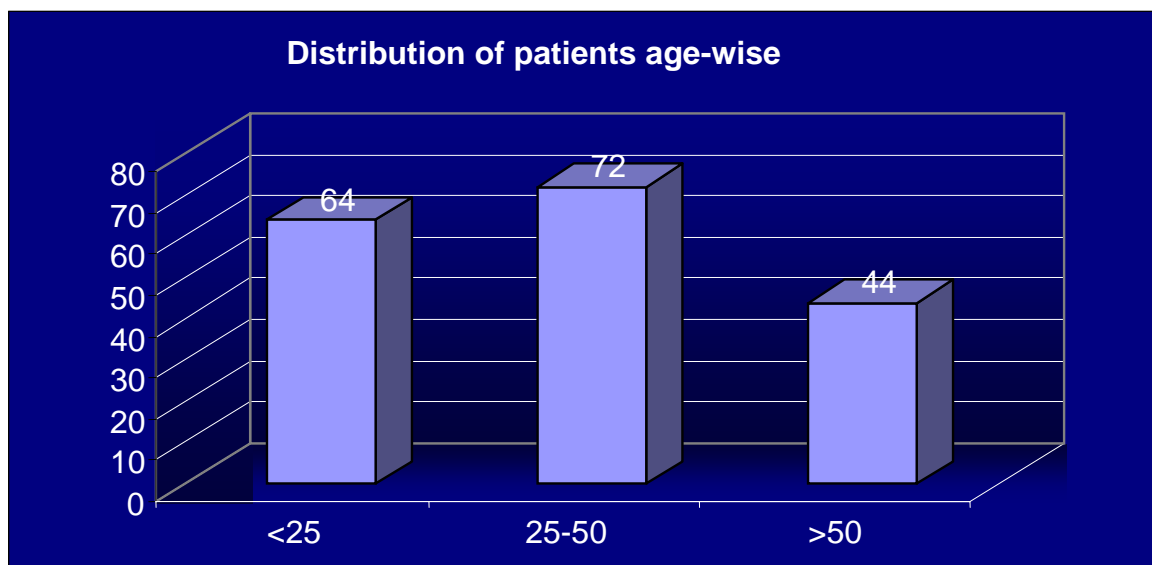
During the period between 2001-2003, 180 patients from either sex reported to the department of Maxillofacial Surgery, Hamburg University. 132 of those patients were women i.e. (73.3%) out of the total number of patients, and 48 of them were men i.e. (26.7%). The study covered all patients.

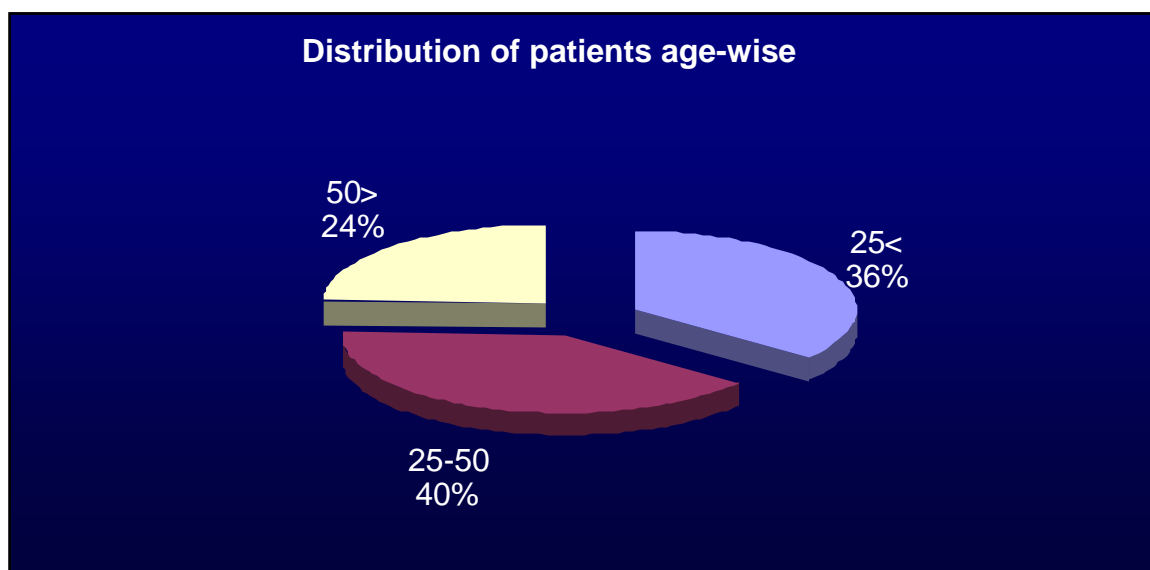




3.2. Distribution of patients age-wise

Out of 180 patients, there were 64 patients of age group less than 25 years, i.e. at a rate of 35.6%, and 72 patients with ages ranging between 25-50 years, i.e. 40% of the total number of patients. The rest of the patients were over 50 years of age, representing 24.4%.





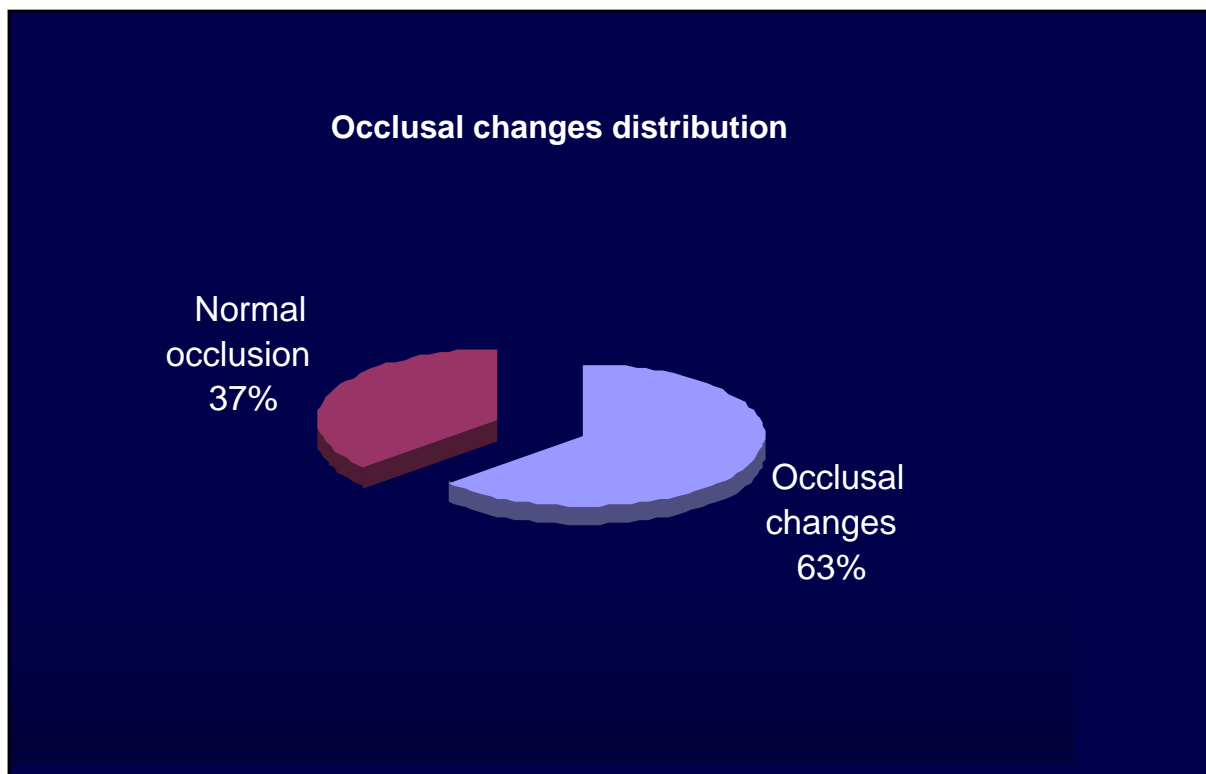
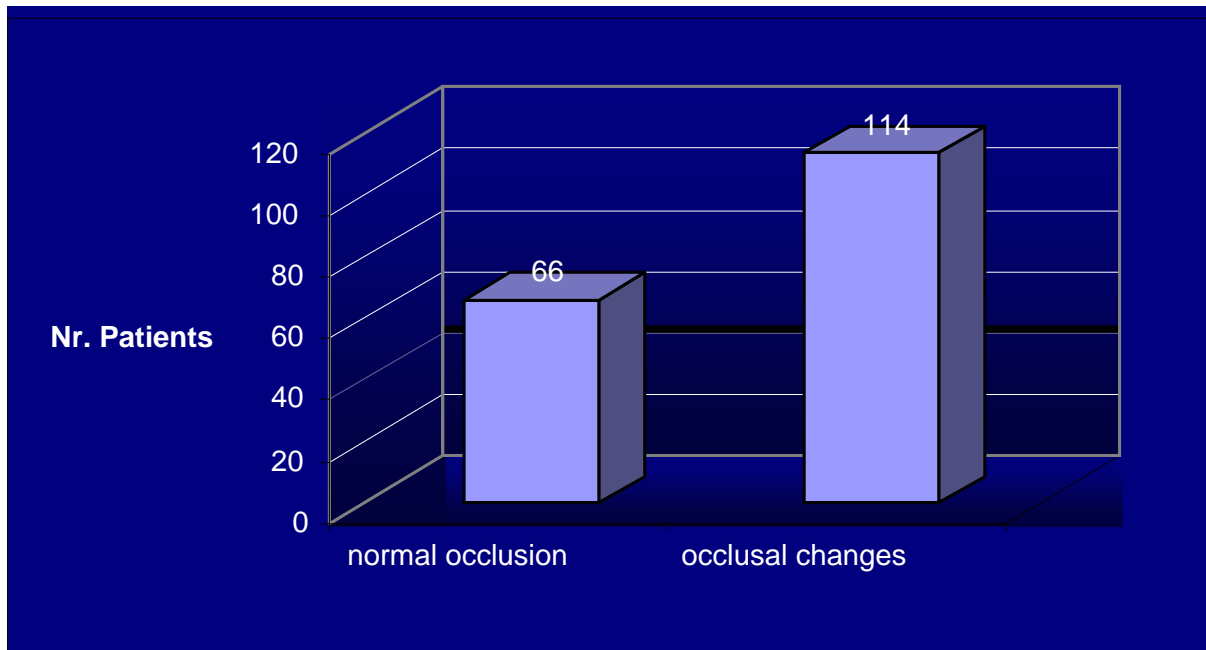
3.3. Occlusal changes

The impact of malocclusion on temporomandibular disorders has been reduced in recent years, however, we cannot ignore that factor in our present study, albeit from a statistical point of view.

The term malocclusion in our study is considered to be more comprehensive than the rest of the other aspects, based upon our belief that any change no matter how marginal, in terms of alignment and location of teeth. The shape of the occlusal surface of the teeth, as well as the alteration of relation to the opposite teeth as a result of fillings and crowns, the vertical distance through total or partial overdentures, and the relation of the two jaws to each other and the Angel classification; will mean a change from the requirement of occlusion. Therefore, the results were as follows:

114 patients 63.3% diagnosed with occlusal changes.

66 patients 36.3% were found to be with unchanged (normal) occlusion.



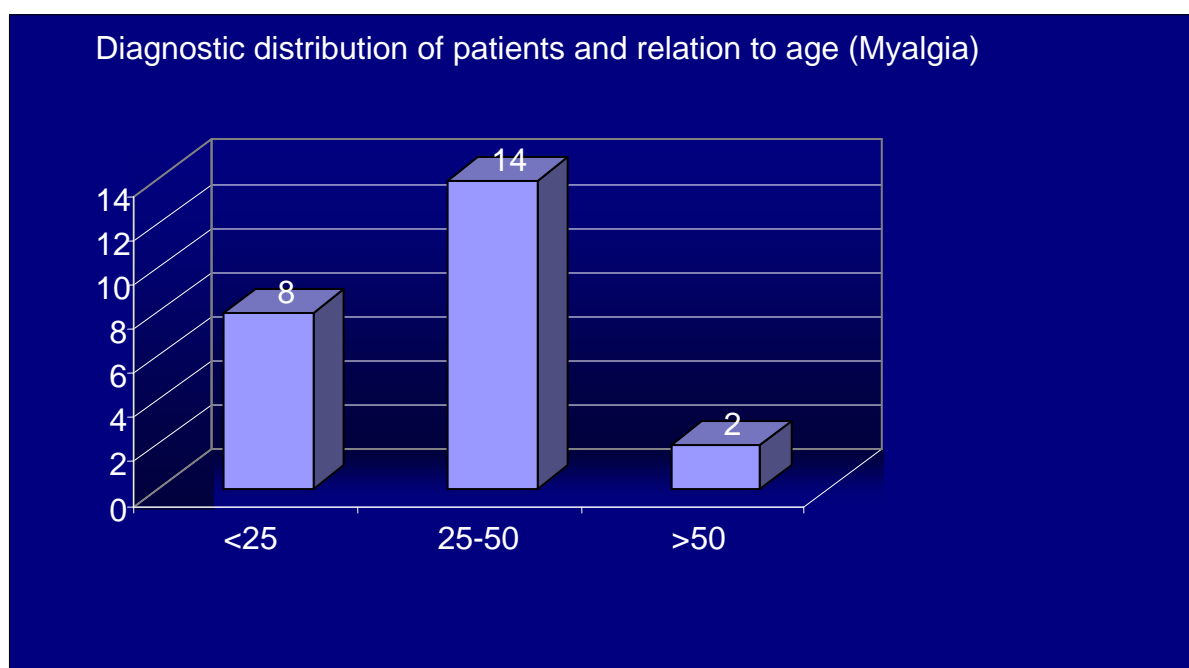
Comment: This agrees with the age distribution carried out in the study, because more than one third of the patients involved in this study were under 25 years, and as such, the likelihood of such patients being subjected to fillings and partial or fixed reconstructions was minimal. Besides, standard of health awareness was high in Germany, especially in the past 30 years, leading the

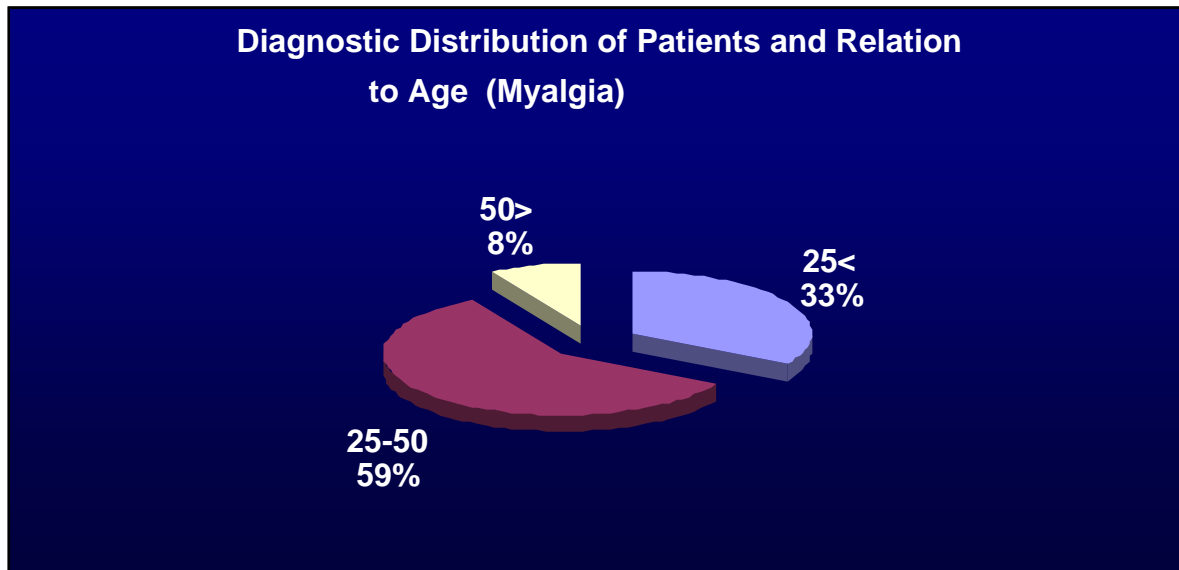
majority of those young patients to undergo regular and periodic teeth treatments and checkups.

3.4. Diagnostic distribution of patients and relation to age

3.4.1. Myalgia

Age	Number of patients	Distribution
Under 25	8	12.5 %
25-50	14	19.4 %
Over 50	2	4.5 %

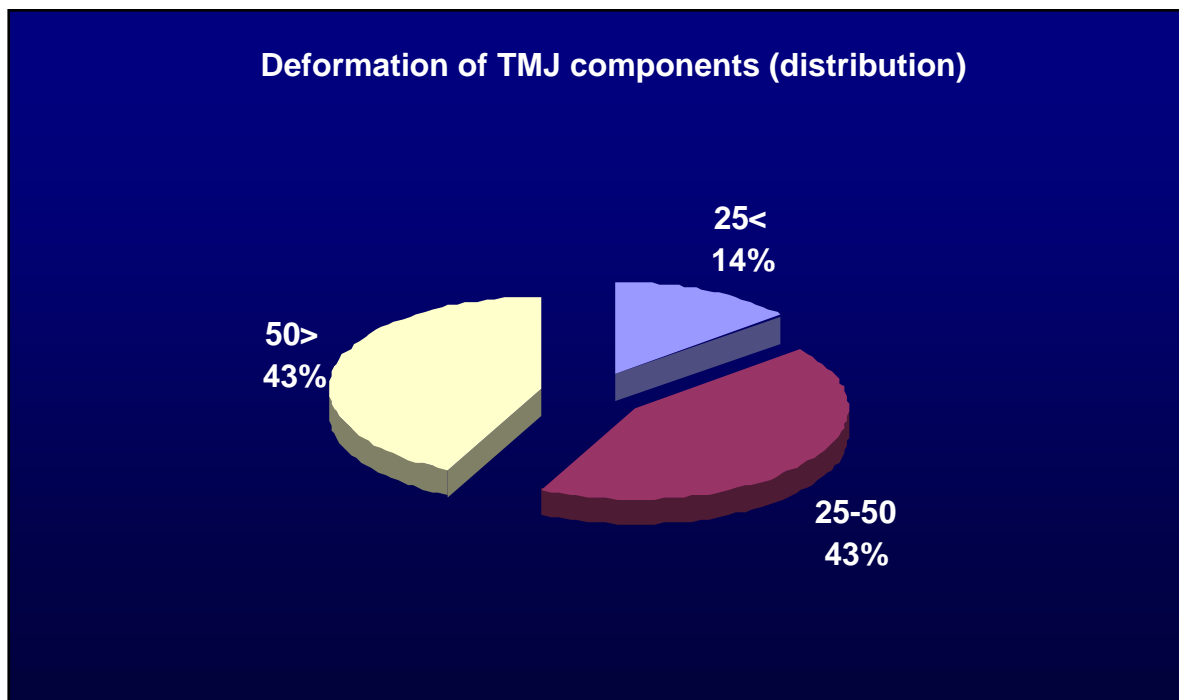
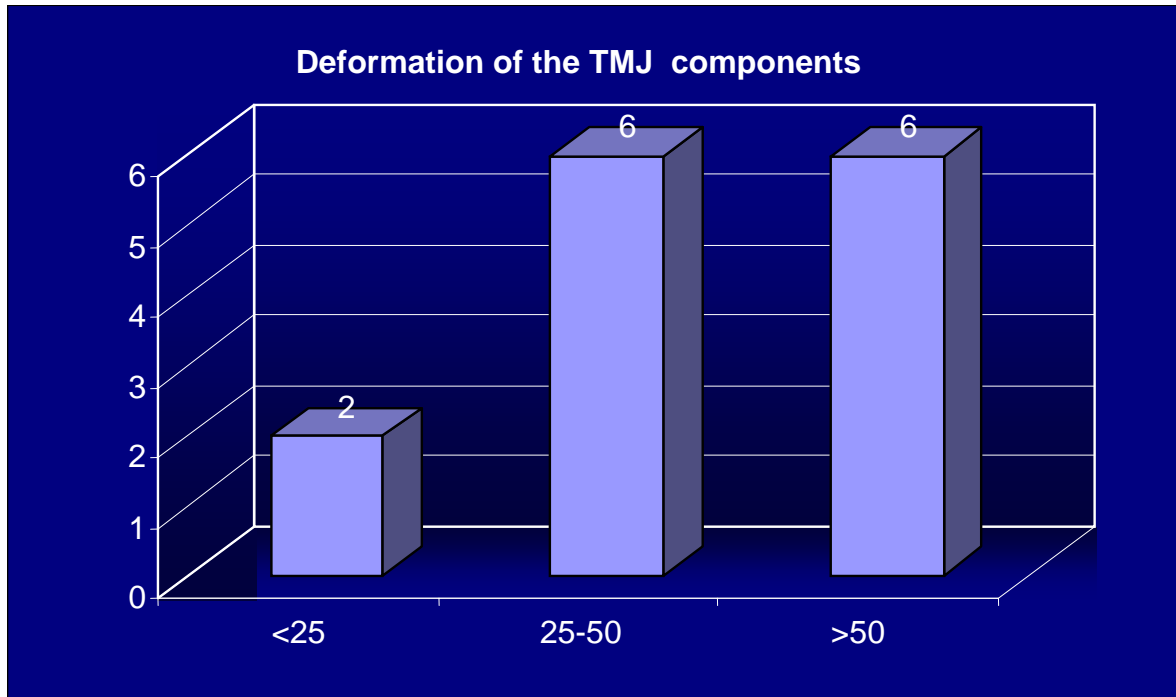




Comment: In an attempt to explain this distribution, it may be said that muscular pain has to do with psychological tension and side activities. We know that young people are less susceptible to tension in general, compared to middle aged people between 25-50, who are usually more exposed to intensified work and day to day social relations. This tension decreases gradually with old age, balanced daily life styles, and retreat of social relationships and day-to-day requirements, conducive to more psychological stability after 50.

3.4.2. Deformation of the temporomandibular joint

Age	Number of patients	Distribution
Under 25	2	3.1 % out of total
25-50	6	8.3 % out of total
Over 50	6	13.6 % out of total



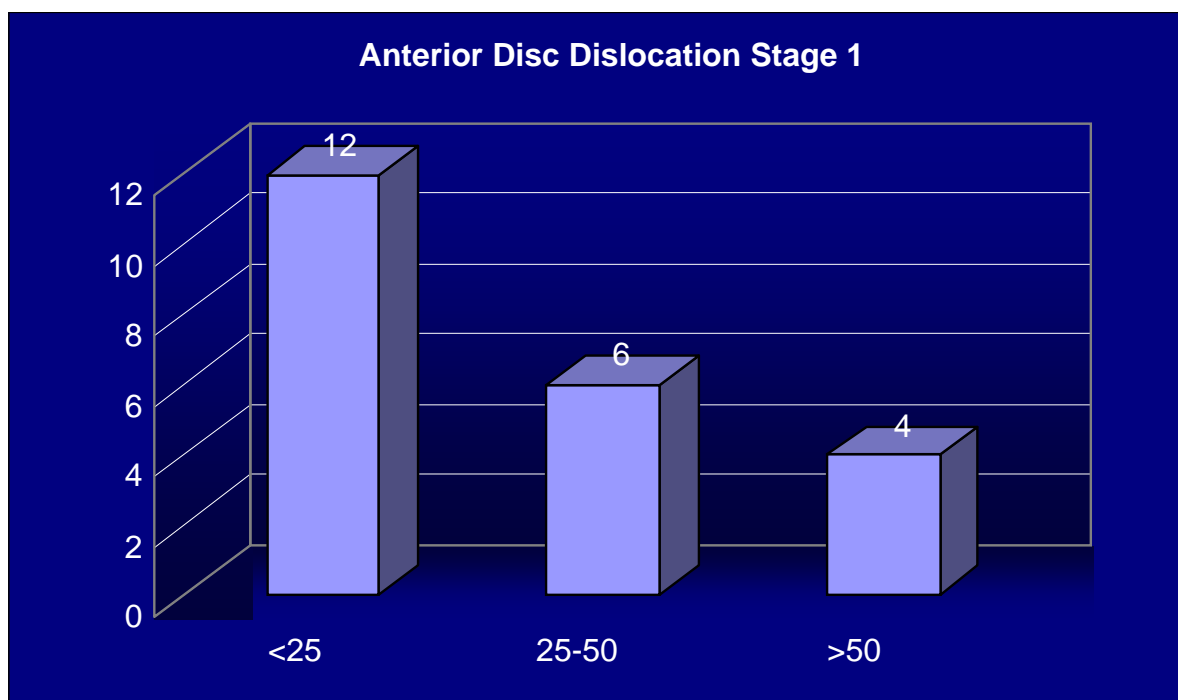
Comment: Aging usually associates with alterations in shape and function of all parts of the body. This may also be associated with the likelihood of persons undergoing various types of joint and other organic ailments, in addition to

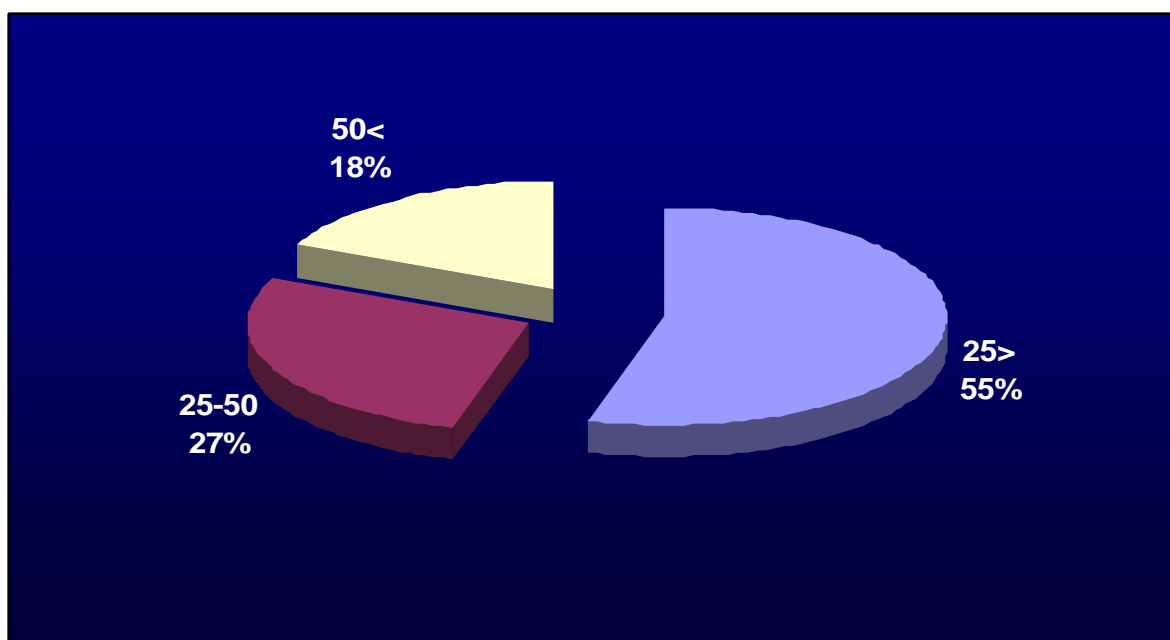
traumatic accidents, that could cause lower jaw fractures in addition to disorders in the temporomandibular joint.

3.4.3. Anterior disc dislocation stage 1 (ADD 1)

Age	Number of patients	Distribution
Under 25	12	18.6 %
25-50	6	8.3 %
Over 50	4	9.1 %

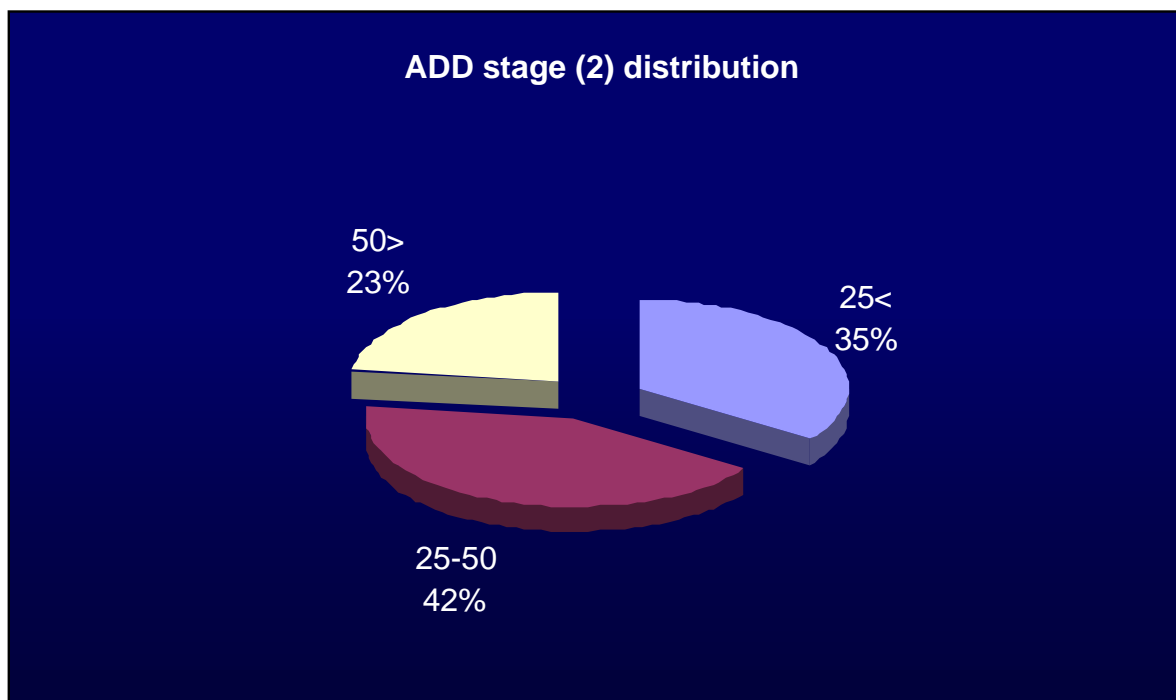
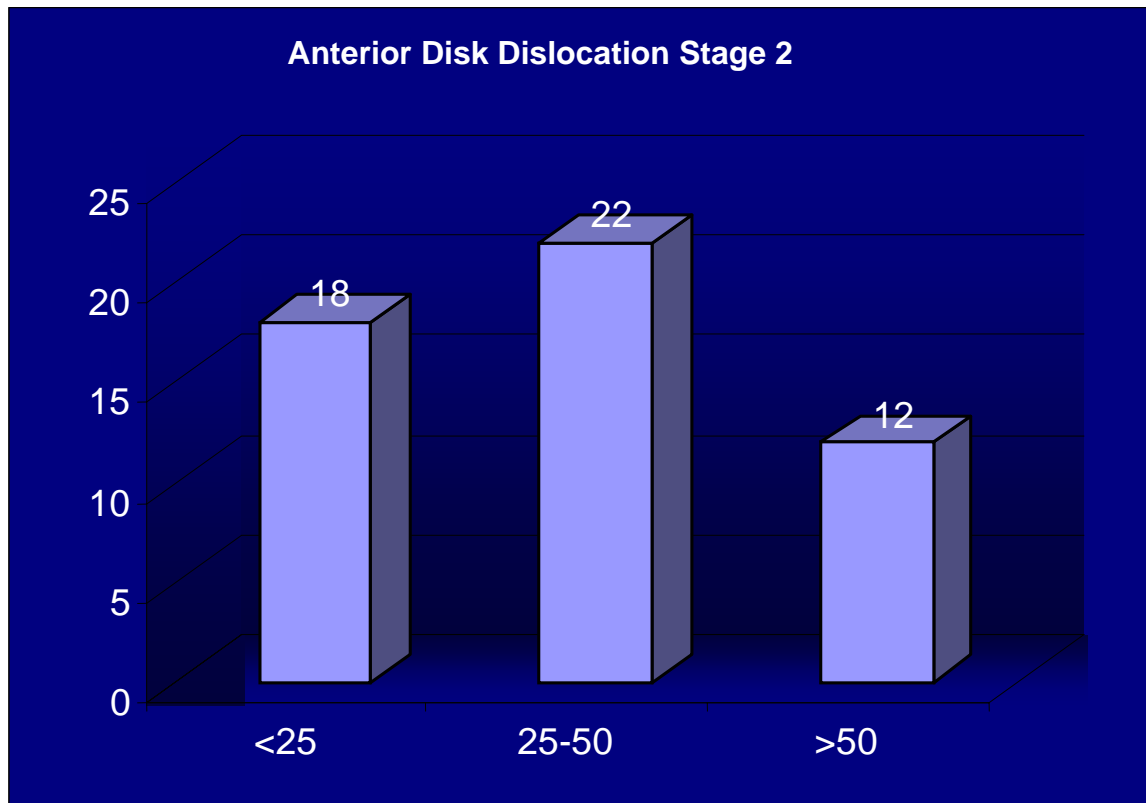
Comment: Occurrence of ADD1 symptoms may most be attributed to some orthodontic treatments or traumatic injuries, which may happen at early ages.





3.4.4. Anterior disc dislocation stage 2 (ADD2)

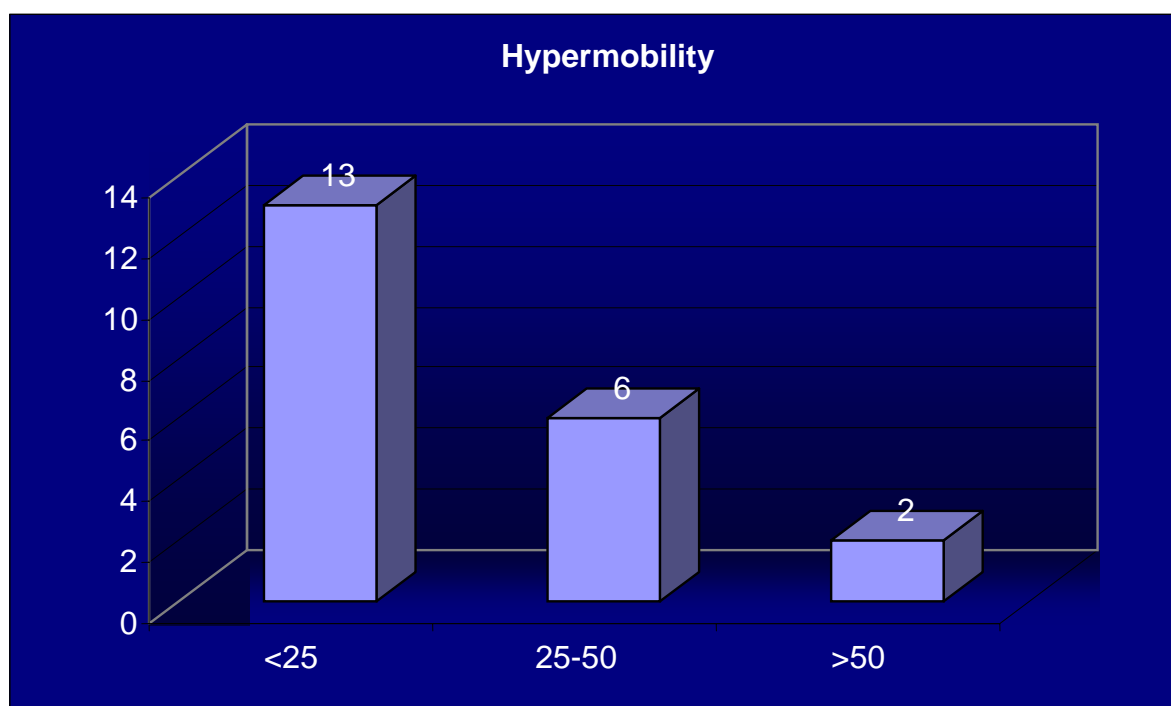
Age	Number of patients	Distribution
Under 25	18	28.1 %
25-50	22	30.6 %
Over 50	12	27.3 %

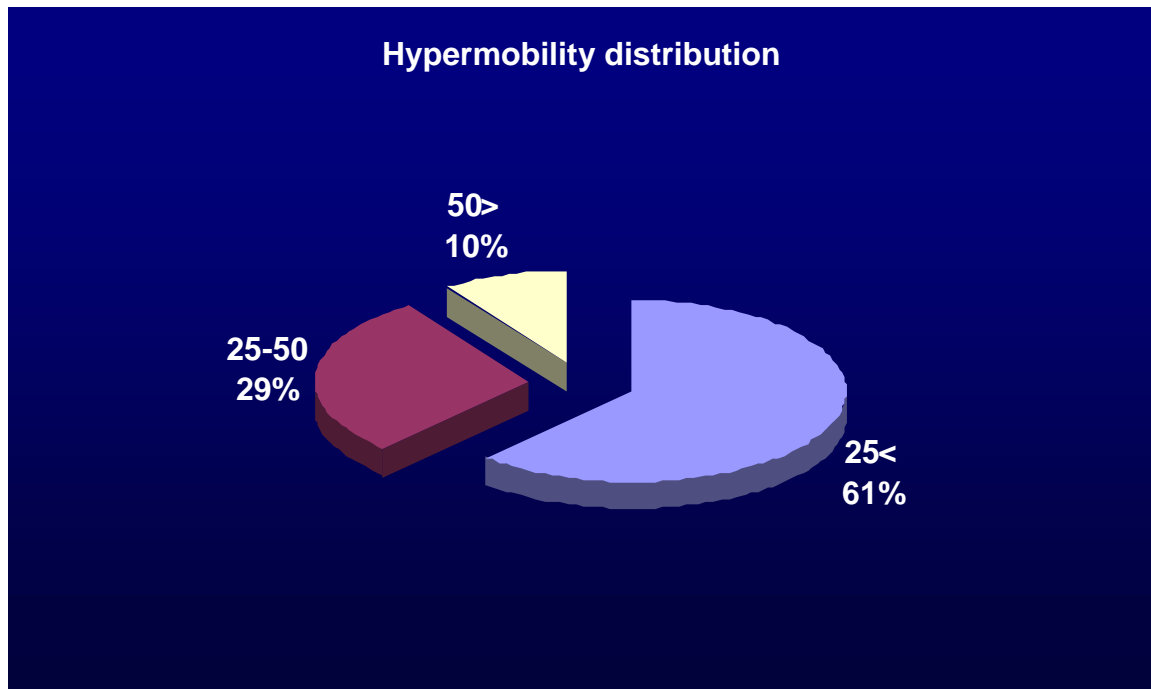


Comment: In an attempt to explain this case one may say that these symptoms are usually an extension and development of a past injury of ADD1, which appear at an early age, later turning chronic, which years later take the shape of ADD2 symptoms in more advanced age groups. They retreat with the passage of time because of organic adjustment, treatment or both these two factors.

3.4.5. Hypermobility

Age	Number of patients	Distribution
Under 25	13	21.8 %
25-50	6	8.3 %
Over 50	2	4.5 %

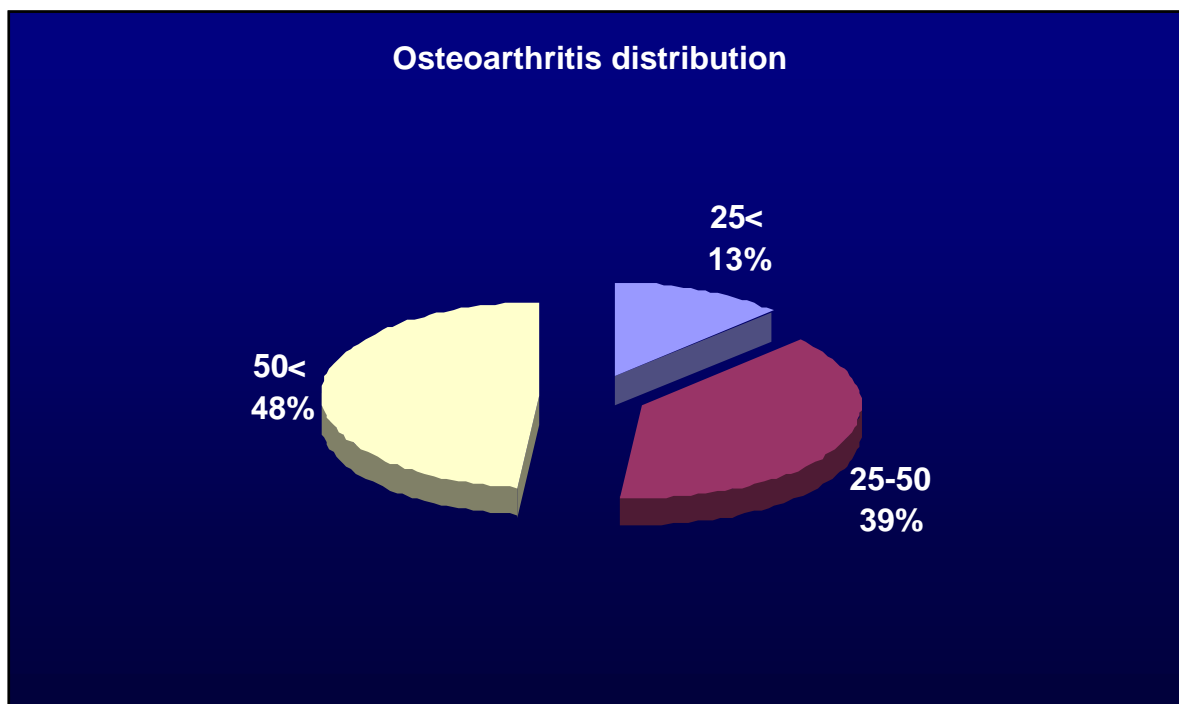
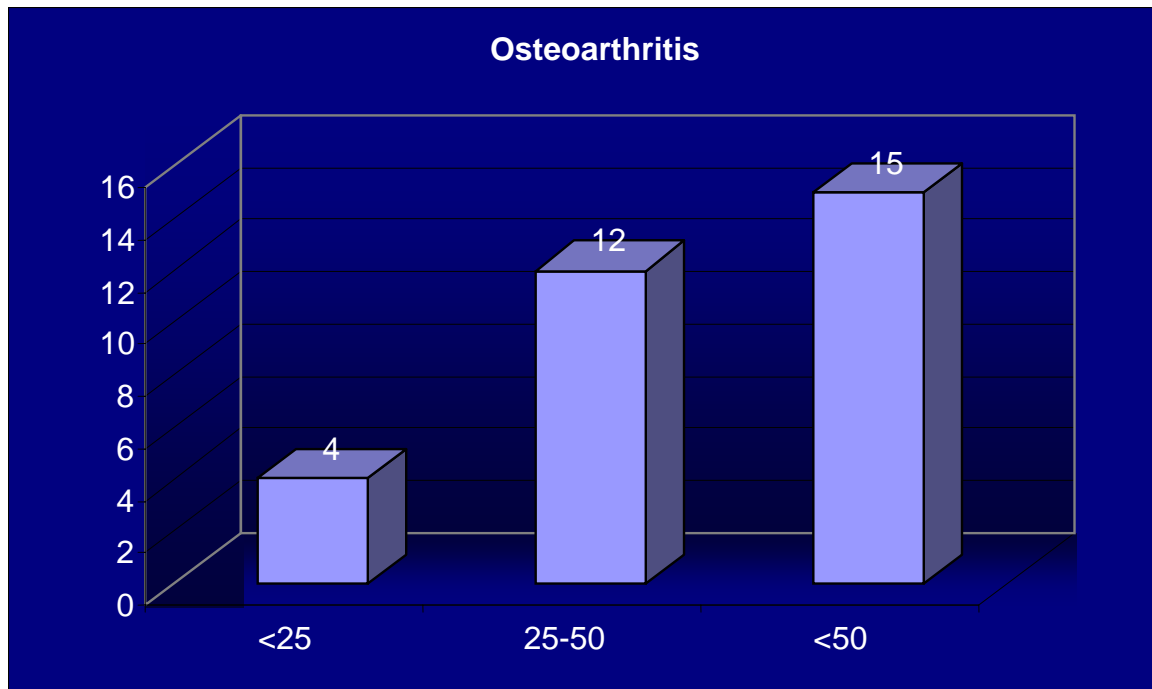




Comment: These symptoms may occur in young patients, whose joint hump of the articular tubercle has not completely grown.

3.4.6. Osteoarthritis

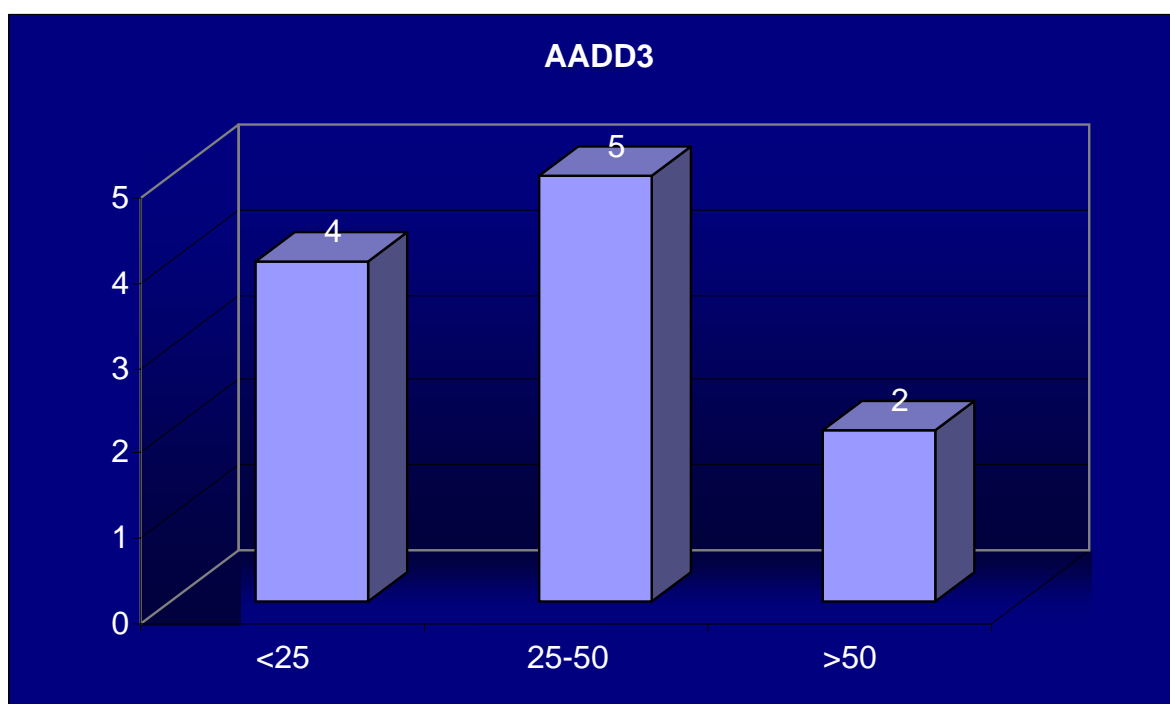
Age	Number of patients	Distribution
Under 25	4	6.2 %
25-50	12	16.7 %
Over 50	15	33.3 %

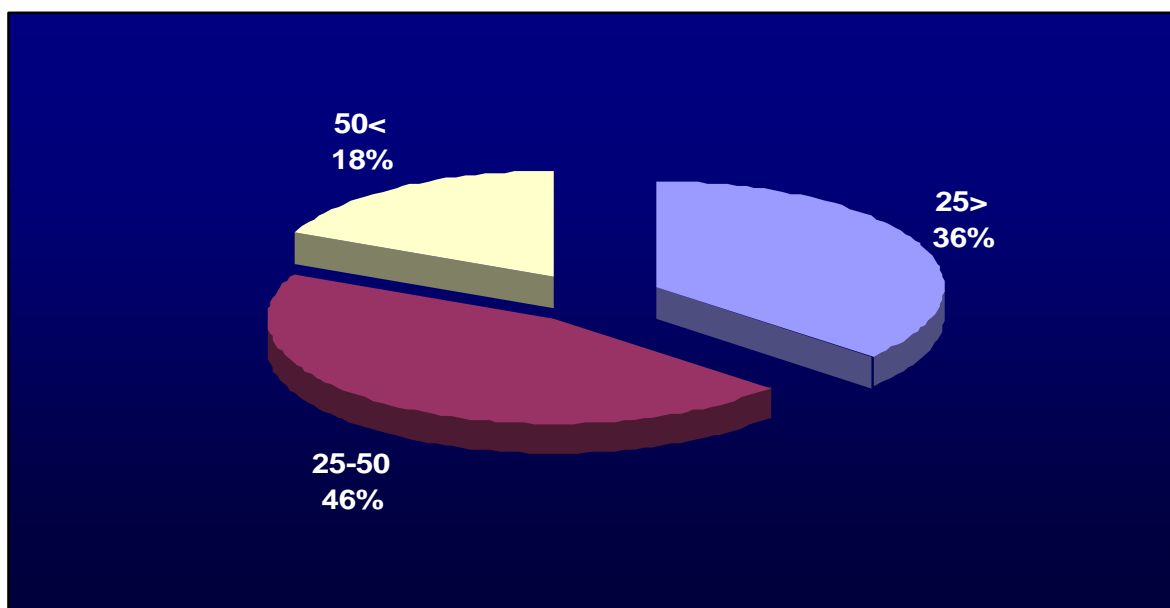


Comment: The incidence to this degenerative disease increases with advancing age, while a low incidence of these alterations exists sometimes in children and the middle-aged.

3.4.7. Anterior disc dislocation stage 3 acute (AADD3)

Age	Number of patients	Distribution
Under 25	4	6.2 %
25-50	5	5.5 %
Over 50	2	4.5 %

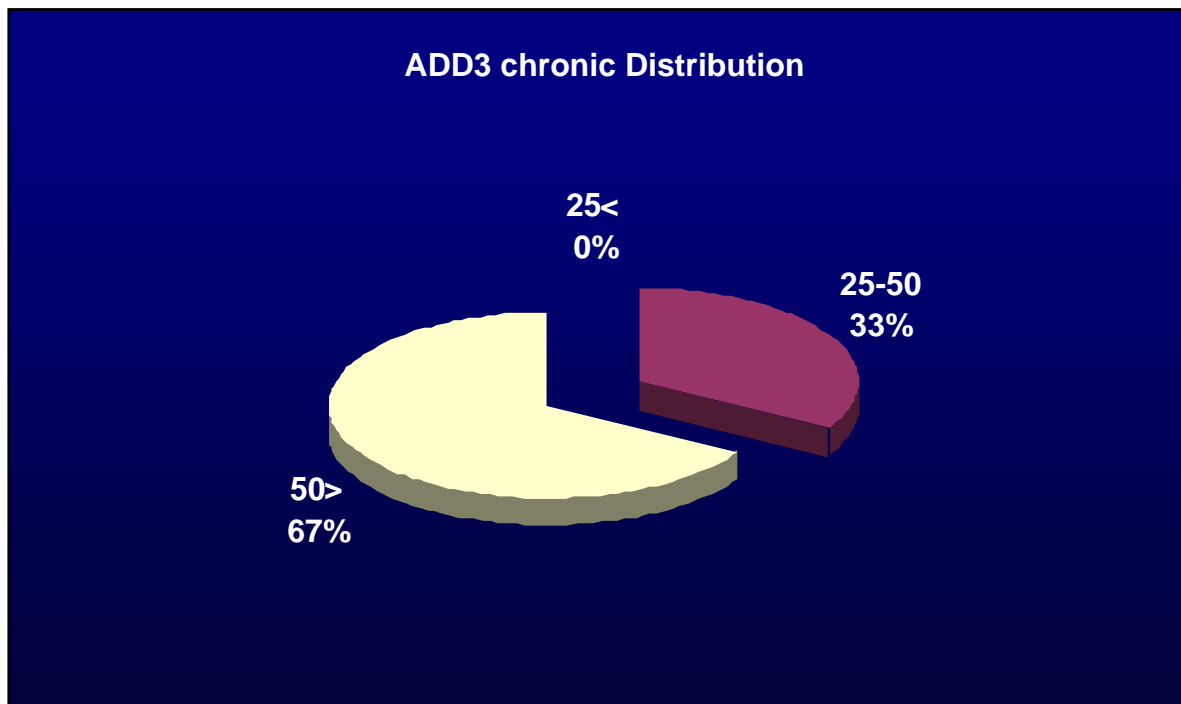
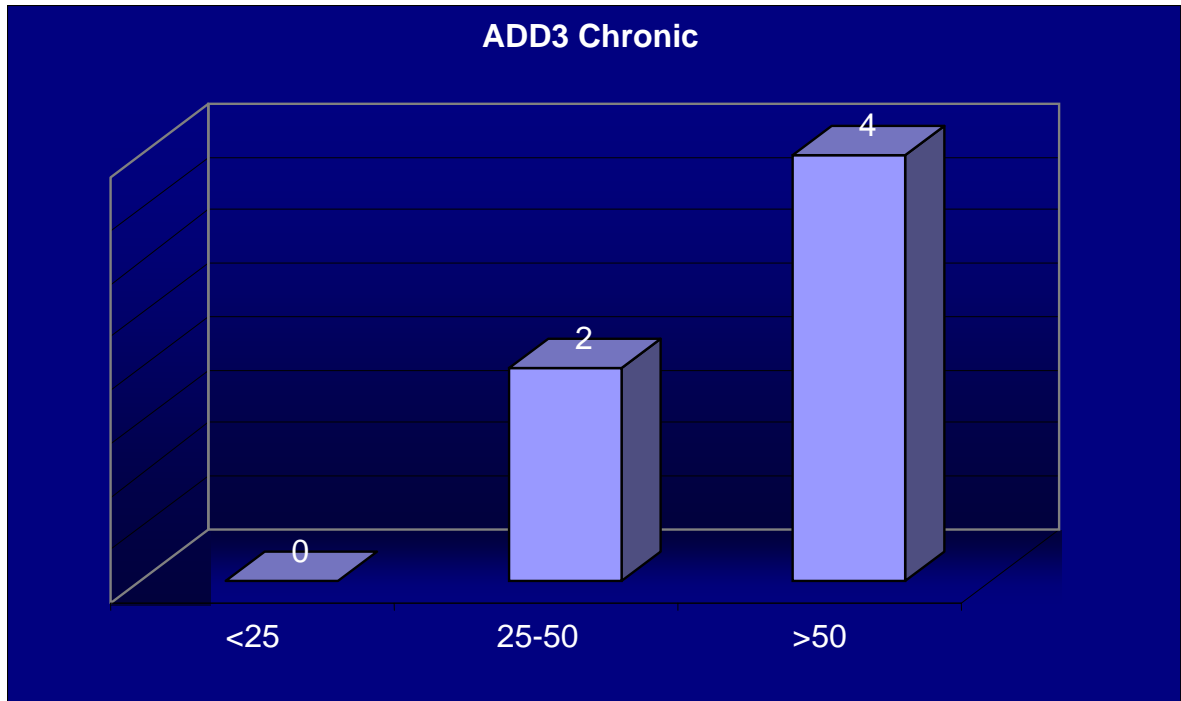




Comment: Symptoms appear in young ages, but in the case of old age groups symptoms will have changed often into a chronic stage.

3.4.8. Anterior disc dislocation stage 3 chronic (CADD3)

Age	Number of patients	Distribution
Under 25	0	3.1 %
25-50	2	5.6 %
Over 50	4	0 %



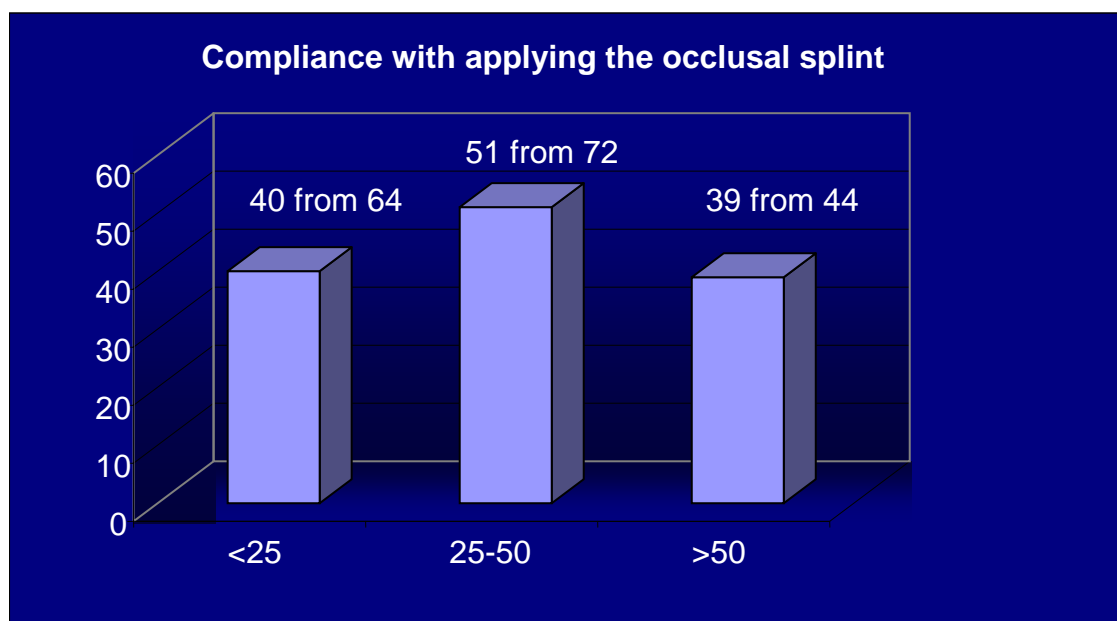
Comment: Acute symptoms often develop into chronic symptoms with advancing age.

3.5. Adherence to applying the occlusal splint

The compliance with the occlusal splint as an essential step in the treatment plan plays an essential role in the success of the treatment.

In this study about relation of age to applying the splint, the following has been found:

Age	Number of patients with abiding for all treatment period	Distribution
Under 25	40 from 64	62.5 %
25-50	51 from 72	69.4 %
Over 50	39 from 44	90.9 %



Comment: We noticed the older the patient, the commitment to implementing the treatment steps (application of the occlusion splint) increases. This can be explained in that the increase in age is usually associated with an increase of patient's attention and health awareness, taking into account the patient's cultural level.

Note: The term "Occlusal Splint" includes in this case the three dimensions used in treatment; namely, 1.5mm, 2.5mm and 3.5mm.

3.6. The impact of thickness of splint on the progress of symptoms

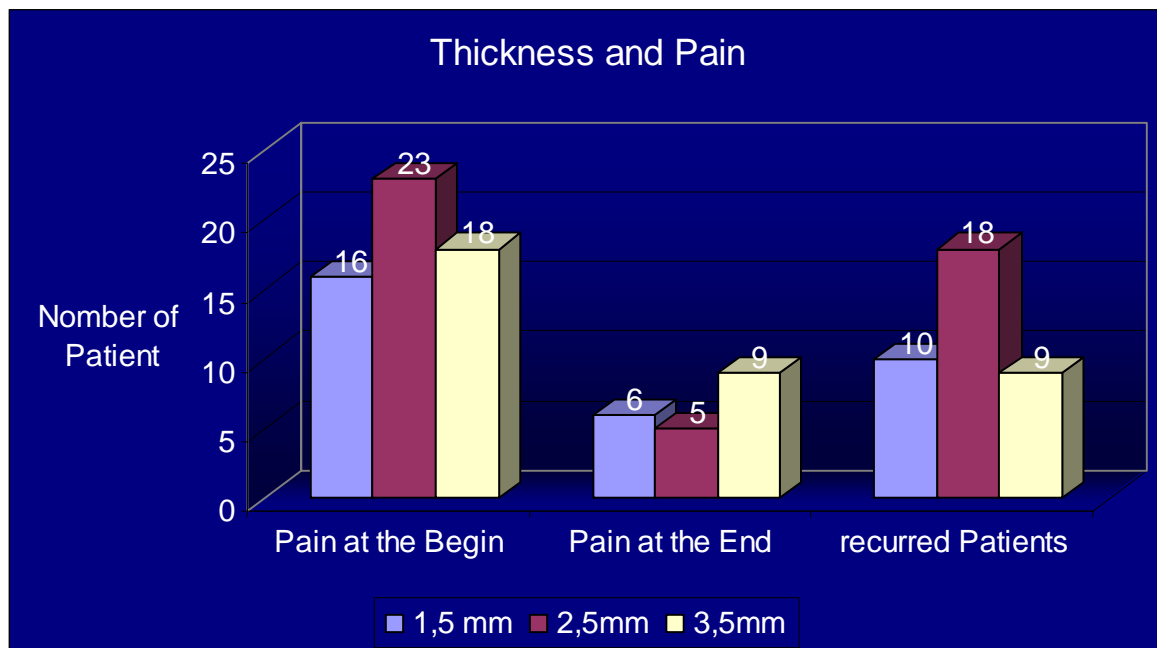
Three types of thickness for the occlusion splint have been adopted in our present study. Patients have also been divided to three groups, each consisting of 30 patients, and patients are evenly distributed age-wise (approximate distribution).

Patients were observed for a period of 6 months as a limited period for treatment with briefing and periodic check-up carried out after two weeks then after four weeks, 12 weeks, and 24 weeks.

Our controlled examination yielded the following results:

3.6.1. Pain

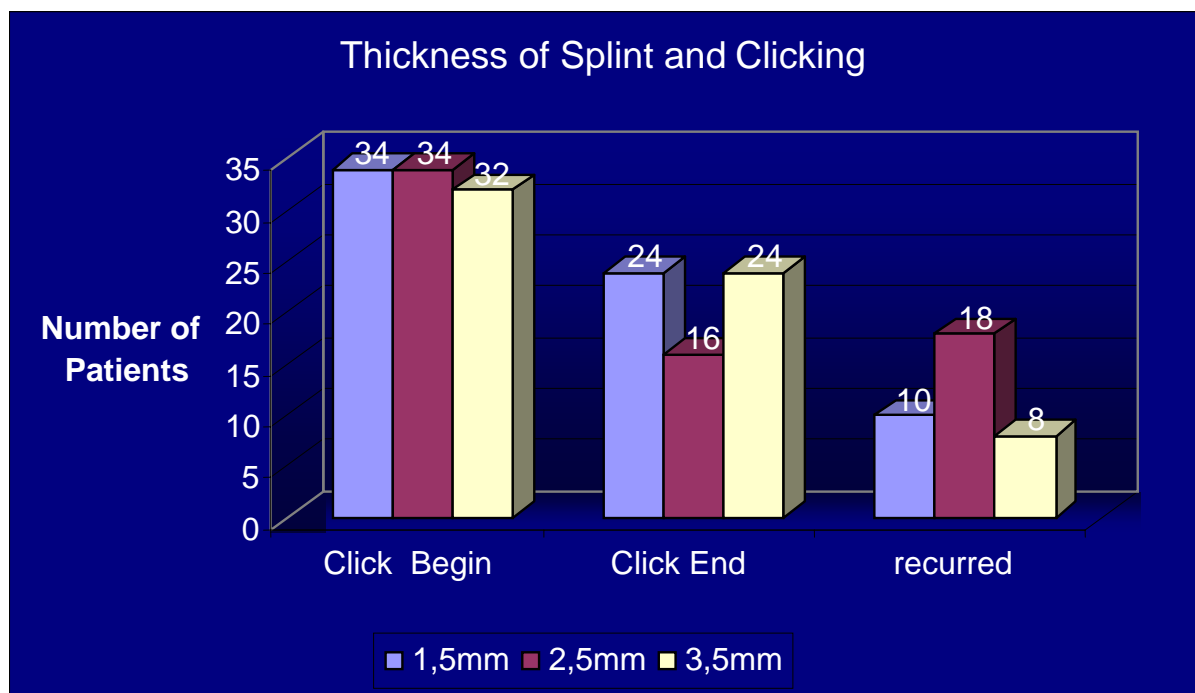
Thickness of splint	Pre-treatment distribution	Post-treatment distribution	Recovery distribution
1.5 mm	16 patients 53.3 %	6 patients 20 %	62.5 %
2.5 mm	23 patients 76.7 %	5 patients 16.7 %	78.2 %
3.5 mm	18 patients 60%	9 patients 30 %	50 %



Comment: We noticed that the 2.5mm thick splint plays an effective role in pain relief and improvement of the patient's condition.

10.6.2. Clicking

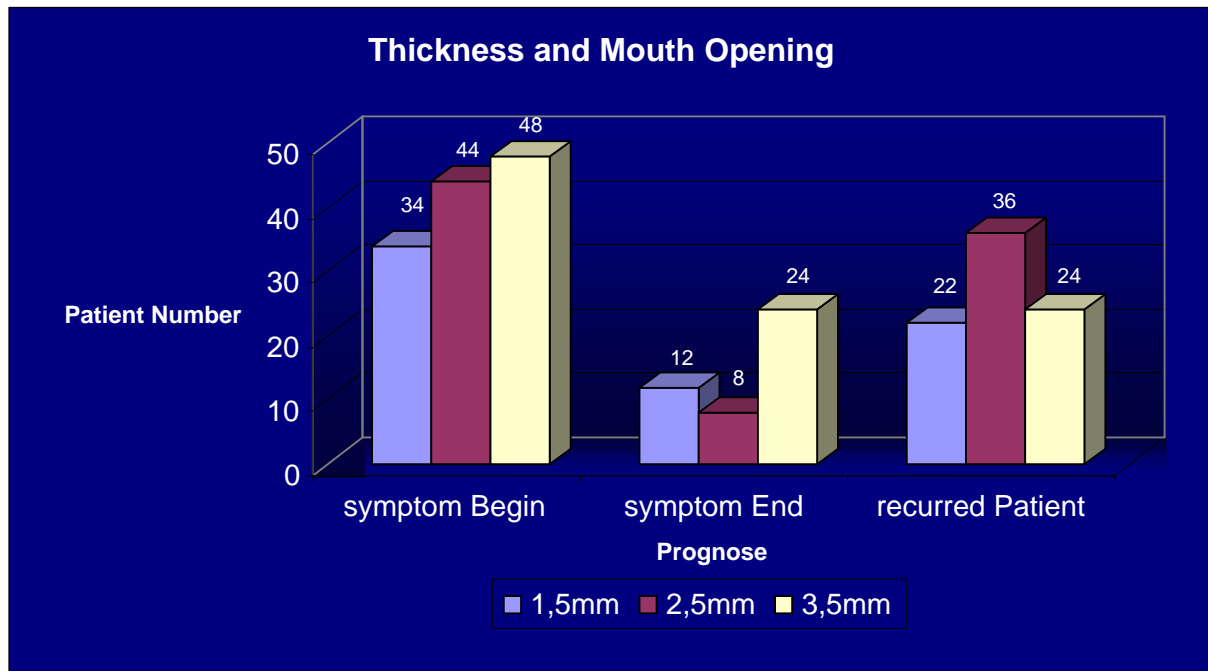
Thickness of splint	Pre-treatment distribution	Post-treatment distribution	Recovery distribution
1.5 mm	34 patients 56.7 %	24 patients 40 %	16.6 %
2.5 mm	34 patients 56.7 %	16 patients 26.7 %	30 %
3.5 mm	32 patients 40 %	24 patients 40 %	22.2 %



Comment: We noticed that the 2.5 mm thick splint plays an effective role in the disappearance of clicking as a symptom.

3.6.3. Limitation of mouth opening

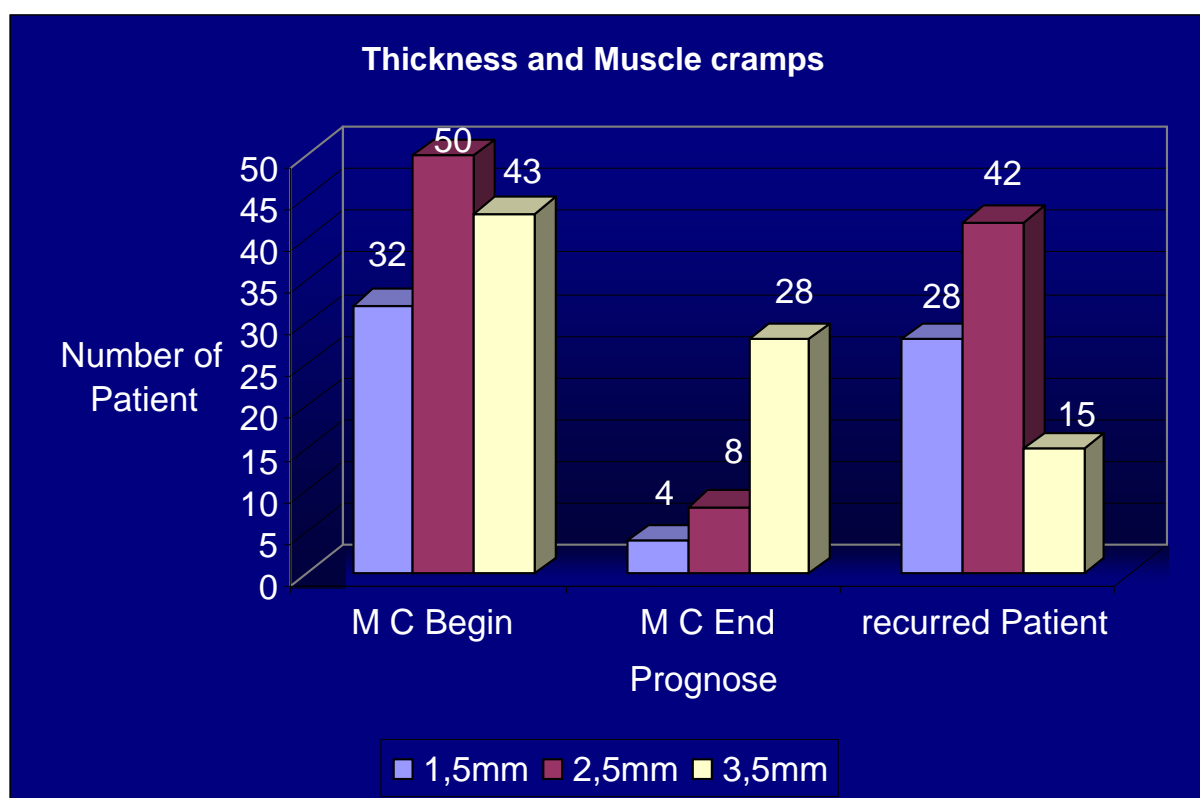
Thickness of splint	Pre-treatment distribution	Post-treatment distribution	Recovery distribution
1.5 mm	34 patients 43.3 %	12 patients 20 %	64.3 %
2.5 mm	44 patients 73.3 %	8 patients 13.3 %	81.8 %
3.5 mm	48 patients 80 %	24 patients 40 %	50 %



Comment: We noticed that the 2.5 mm thick splint plays an effective role in elimination of movement limitation of the mouth or improvement of it as a symptom.

3.6.4. Muscle cramps

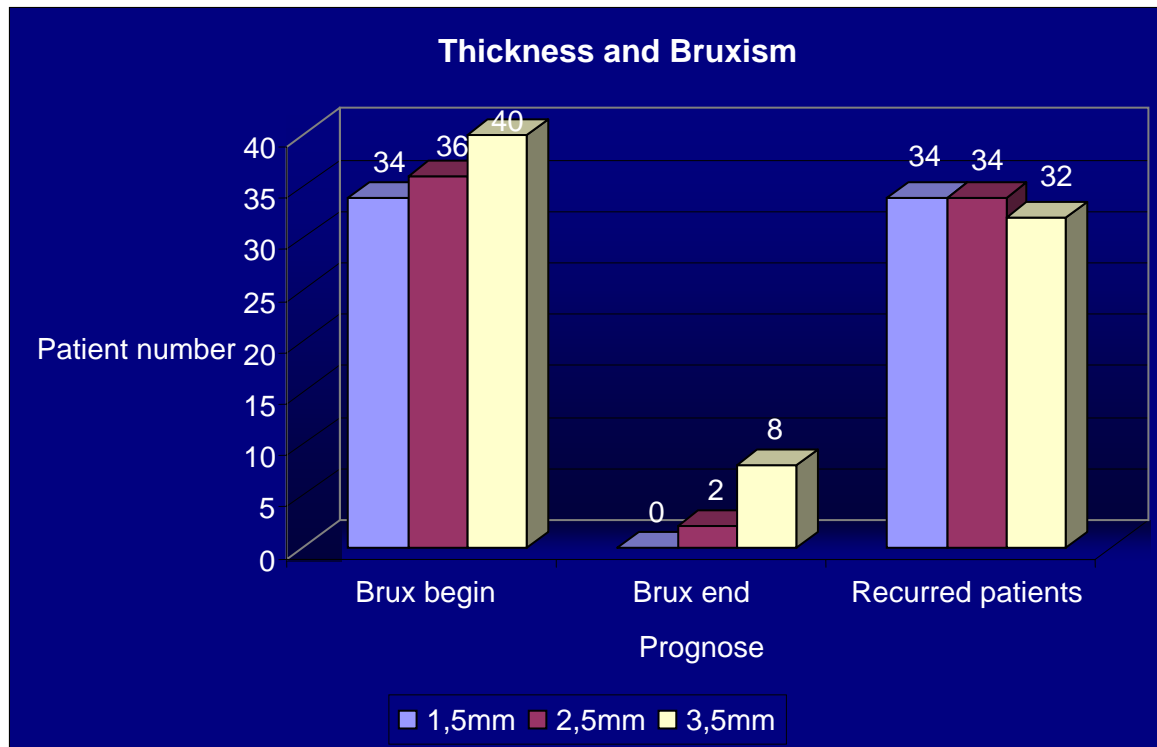
Thickness of splint	Pre-treatment distribution	Post-treatment distribution	Recovery distribution
1.5 mm	32 patients 43.3 %	12 patients 93.3 %	87.5 %
2.5 mm	50 patients 83.3 %	8 patients 13.3 %	84 %
3.5 mm	43 patients 70 %	27 patients 46.7 %	33.3 %



Comment: we have noticed that the first and second splints have yielded a clear decrease in the symptoms compared to the third splint.

3.6.5. Bruxism

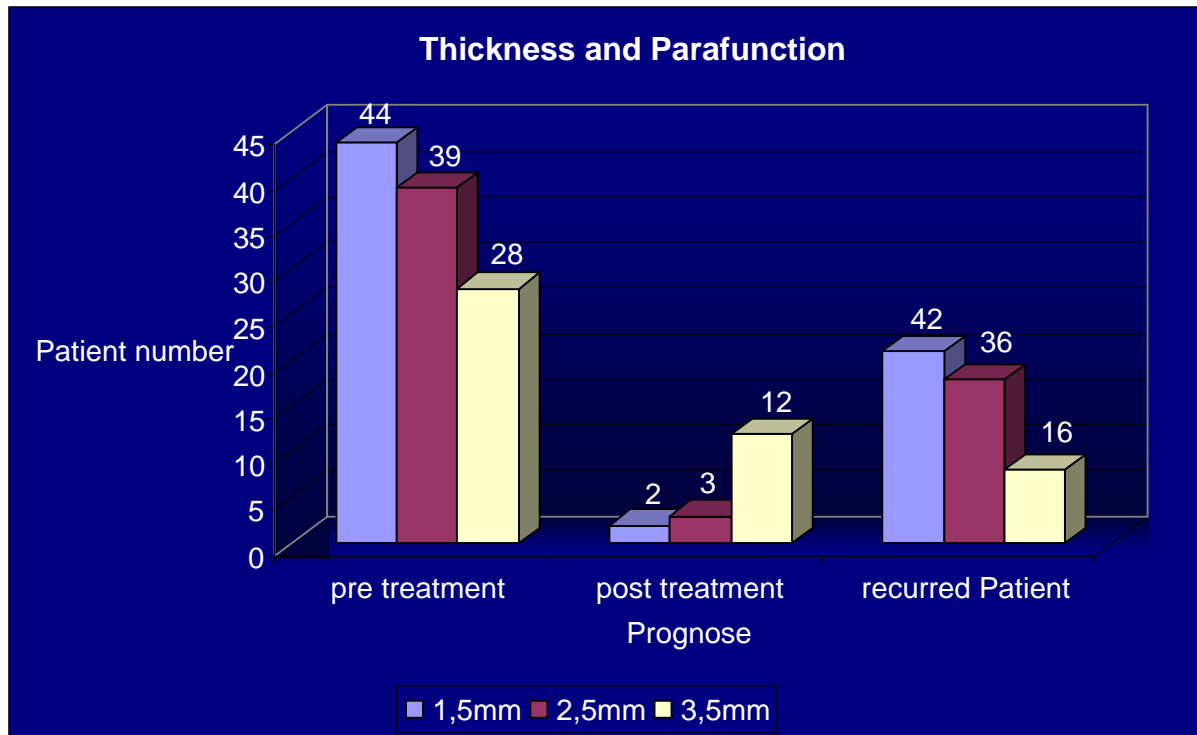
Thickness of splint	Pre-treatment distribution	Post-treatment distribution	Recovery distribution
1.5 mm	34 patients 56.7 %	0 patients 0 %	100 %
2.5 mm	36 patients 60 %	2 patients 3.3 %	94.4 %
3.5 mm	40 patients 66.7 %	8 patients 13.3 %	80 %



Comment: we noticed that the distribution of patient recovery is higher in groups 1 and 2 compared to group 3.

3.6.6. Parafunction

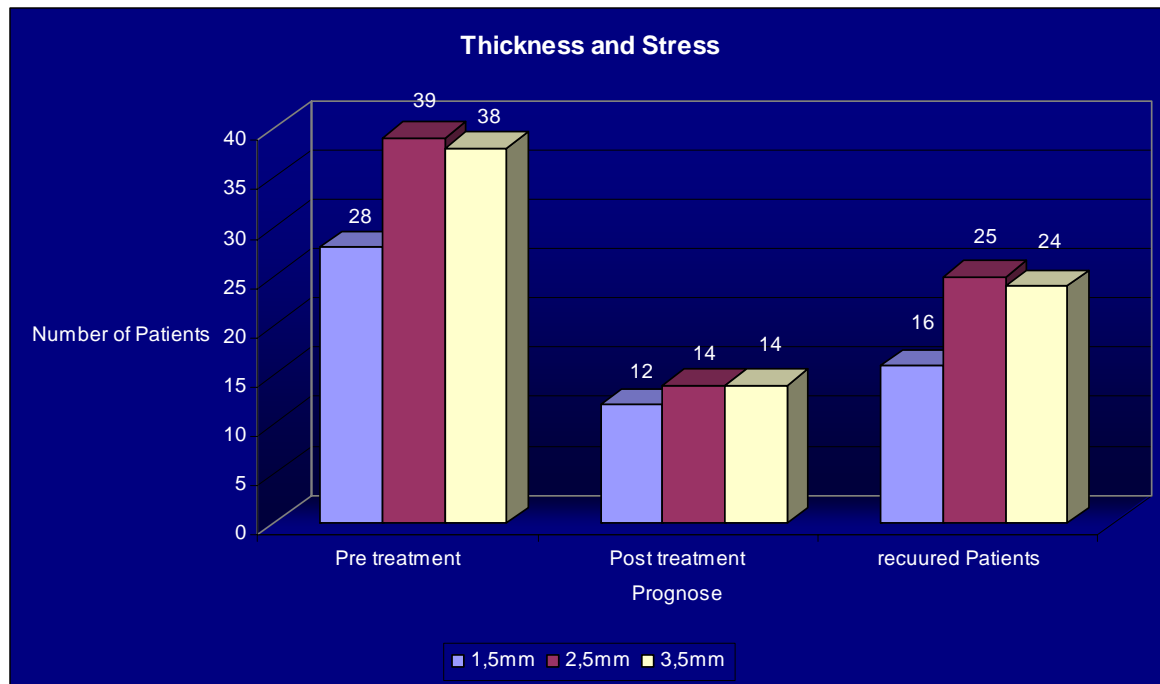
Thickness of splint	Pre-treatment distribution	Post-treatment distribution	Recovery distribution
1.5 mm	44 patients 73.3 %	1 patients 3.3 %	95.4 %
2.5 mm	39 patients 63.3 %	1 patients 33.3 %	94.4 %
3.5 mm	28 patients 46.7 %	6 patients 20 %	57.1 %



Comment: we noticed that percentage of recovery in groups 1 and 2 had been close to each other, in comparison with group 3.

3.6.7. Stress

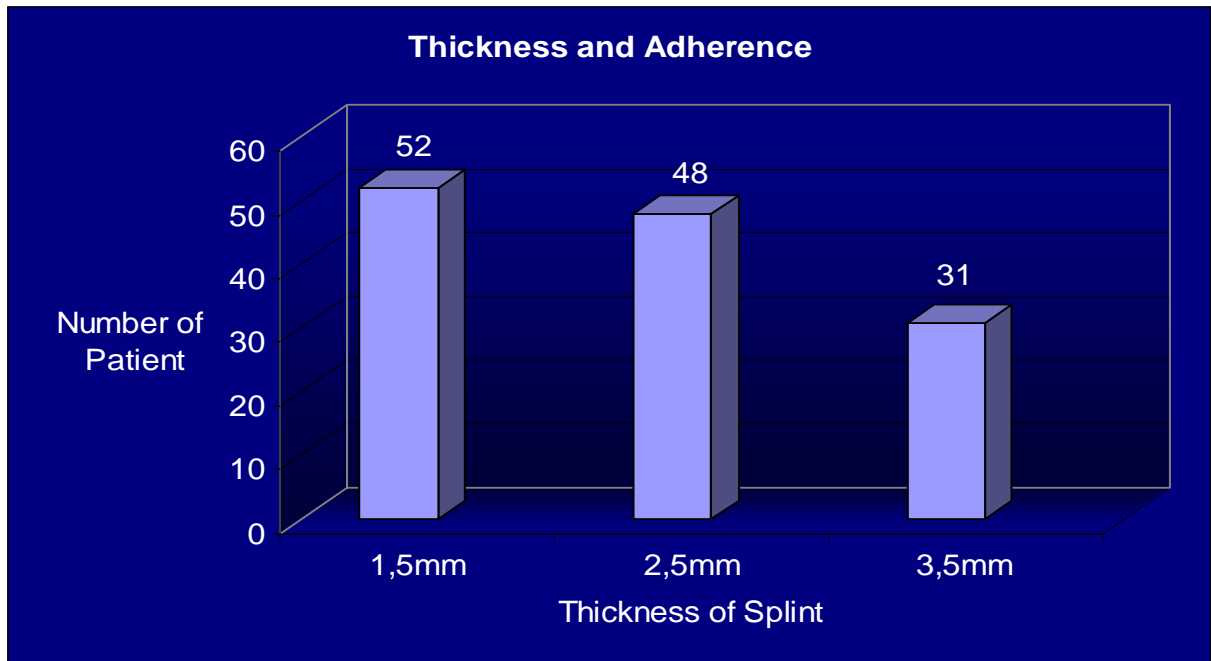
Thickness of splint	Pre-treatment distribution	Post-treatment distribution	Recovery distribution
1.5 mm	28 patients 46.7 %	12 patients 20 %	42.8 %
2.5 mm	39 patients 62.1 %	14 patients 23.3 %	63.1 %
3.5 mm	38 patients 62.1 %	14 patients 23.3 %	63.1 %



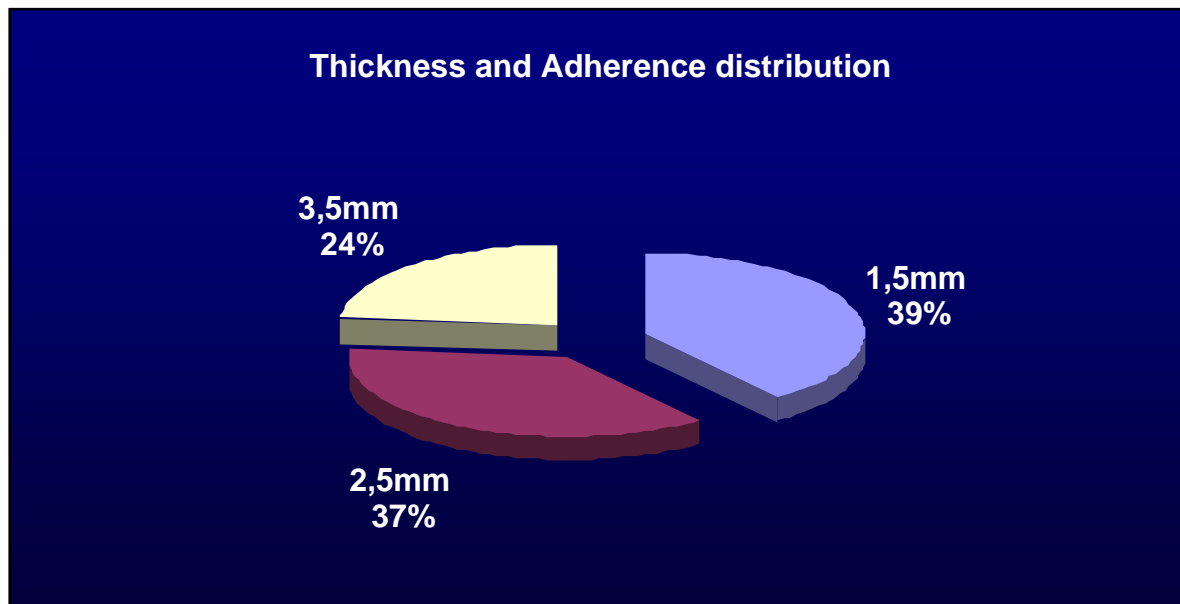
Comment: we noticed that the recovery rate is equal in-group two and three, and are higher than recovery rate in-group 1.

3.7. Adherence to application of splint round the clock for 6-month

Thickness of splint	Number of patients	Distribution of adherence
1.5 mm	52	86.6 %
2.5 mm	48	80 %
3.5 mm	31	50 %



Comment: we noticed that adherence to application of the splint decreases with an increase in the thickness of the splint



3.8. Thickness of the splint and the success of treatment

The success of the treatment follows injuries of temporomandibular joint, and the pain of mastication has varying levels, depending on the percentage of disappearance of symptoms, which caused the patient to report to the doctor.

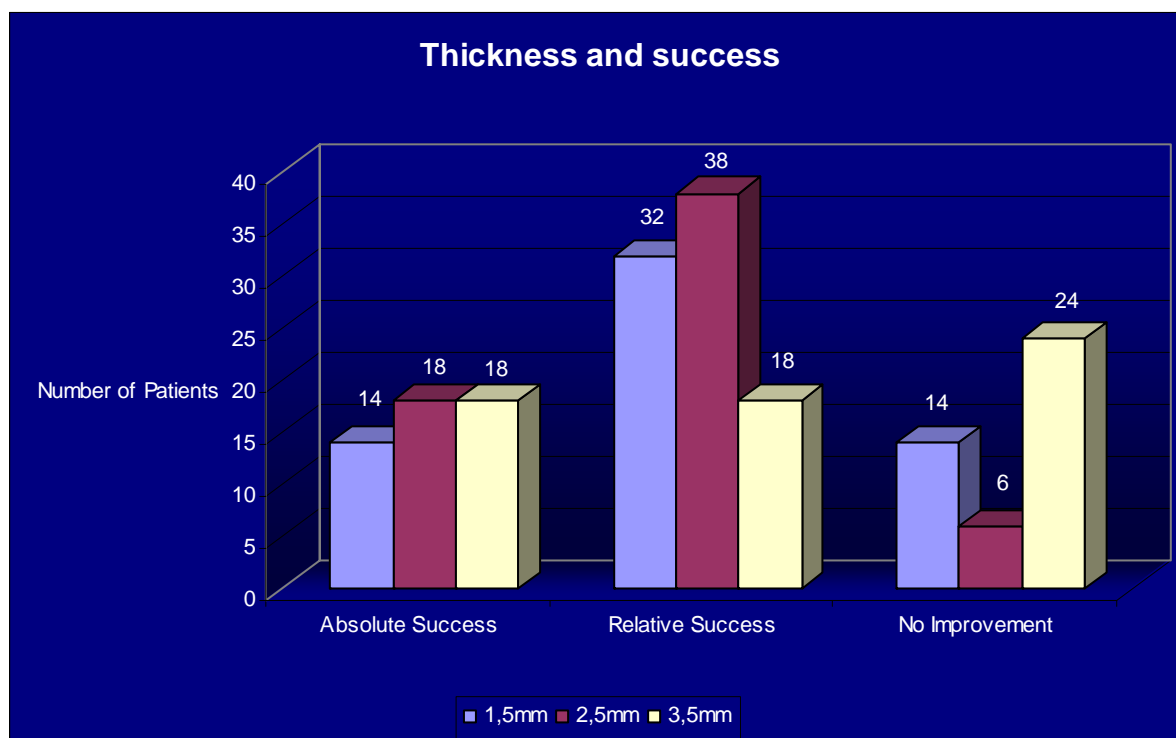
These can be prioritized as follows:

Pain limitation of the mandibular movements, and clicking or crepitation as major symptoms.

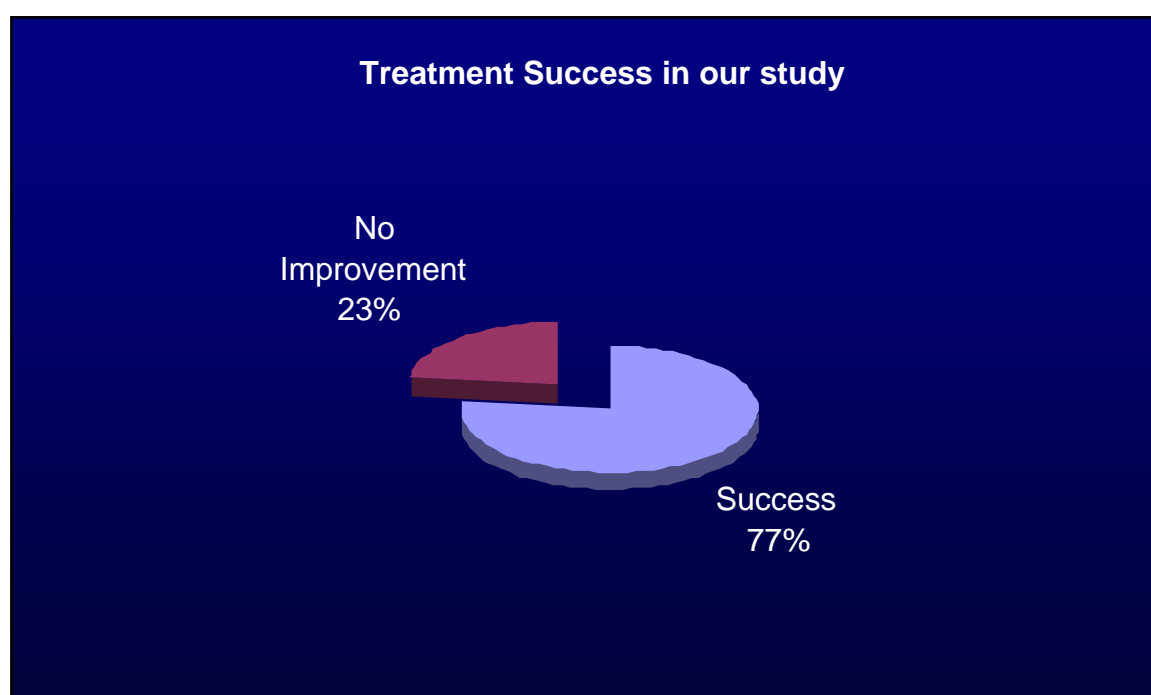
In this study, we have relied upon the disappearance of these symptoms as a whole or in part for evaluating the extent of success of the treatment:

1. Absolute success: Disappearance of all forementioned symptoms.
2. Relative success: With some of the previous symptoms remaining.
3. Lack of improvement: The previous symptoms persist and no improvement is achieved.

Thickness of splint	Absolute success	Relative success	No improvement
1.5 mm	14 patients 53.3 %	32 patients 53.3 %	14 patients 23.3 %
2.5 mm	38 patients 63.3 %	38 patients 63.3 %	6 patients 6.7 %
3.5 mm	18 patients 30 %	18 patients 30 %	24 patients 40 %



Comment: we noticed that the 2.54 mm-thick splint is most effective. In general, we may say that the percentage of success according to our study, regardless of the dimensions of the splint is 76.7%, while no improvement has been achieved in 23.3% of the patients.



4. Discussion

4.1. Distribution of gender

The volume of the sample involved in the study reached 180 patients, who had been subjected to treatment of functional disorders of the temporomandibular joint in the Department of Oral and Maxillofacial Surgery, University of Hamburg-Eppendorf.

They were suffering from complaints in the region of the temporomandibular joint. They were distributed in terms of sex to 73.3% women and 26.7% men. This means that the majority were women. This distribution falls in line with the outcome of the statistical reports of previous studies, without a large-scale deviation, especially in relation to the study of: De Boever U. Andrians 1983, Bernstein 1983, Schulte 1981, Schubert 1980, and Friedrich 1994.

The studies indicated that the distribution ratio is one man to three women. Other studies mentioned that the distribution was one man to four women. Among these studies was Lee [84], while the results of our study differs from those mentioned by Rieder U. Martinof [107], who concluded that the ratio is one man to two women.

A number of researchers have attempted to justify this distribution:

- Weinberg u. Lager [141] mentioned that the number of women visiting doctors' clinics is larger than that of men, due to women having sufficient time to do so. Previously, Heloe. and Heloe 1975 mentioned the same thing.
- Schlegel [110] mentioned that the hormonal factors play a role in that.
- Hansson [59] mentioned that histological factors have a role.
- Helkimo [63,64] and Rieder [107], mentioned that gender has nothing to do with the distribution of symptoms. They rather emphasized that the symptoms existed in both sexes at almost identical rates, when taking random samples out of hospitals and clinics.

4.2. Age distribution

The highest percentage among patients was found to be in the age group 25 to 50 years. That percentage reached 40%, followed by patients younger than 25 (35.6%). The least percentage (24.4%) was for patients over 50 year.

This distribution is in line with the international studies, which say that the majority of patients' age group range between 20 to 50. Among such studies are:

Schulte [120]/ Lee.a. Lee [84] / Friedrich [44] / Siebert 1989.

Attempting to explain this patient distribution age-wise, we may say that in most cases symptoms become more evident and the complaint occurs years after the incidence of affliction - chronic progression of the disease when the patients have reached middle age (25-50) with the development of health awareness which contributes to patients' recurrent visits to clinics.

However, at the early stages of the disease, when the symptoms are either hidden or unclear and recurring, the young patients who tend to defer doctor's visit until the symptoms become evident and more intense years later, when their age group falls into the 25-50 category, ignore them.

The clear decrease in respect to patients with 50-plus of age (24.4%) is often attributed to such patients having been previously subjected to past treatments with satisfactory results, or to the chronic nature of the disease and the patient's adjustment to the condition behaviorally and psychologically contributing to his coexistence with his ailing condition.

4.3. Symptoms

We noticed throughout our study that the most common symptom among patients is muscular contraction and the facial and neck pain associated with it.

The percentage of patients who suffered from muscular cramps and facial and neck pain reached 68.5%; and as this symptom was evidently linked to the

psychological situation and tension as well as to the grating and parafunction, these being subsequent symptoms or precursors, the rate of occurrence of these symptoms matched the aforementioned percentage. The percentage of patients who suffered psychological tension has come up to 56.2%, and percentage of patients with nocturnal gritting is 61.1% and patients with parafunction comes to 61.1%.

The proximity in percentages of such patients is logical.

The muscular parafunction occurs as an attempt to discharge the psychological pressures undergone by the patient during his day-to-day living and intensified social encounters (Dawid et al [35]).

We found that most patients who have suffered psychological tension have clear precursors of muscular parafunctions (abrasion), especially at the frontal teeth, canine teeth and premolars. In addition, on clinical examination, the muscular pain suffered by the patients was evident when examining the facial, neck and shoulder muscles.

On hearing the clinical history of the patients, many of them stated that they often press the jaws and teeth against each other to try to discharge the pressures.

Pain plays the most important role in pushing the patient to visit the doctor immediately. Upon studying this symptom and the extent of its spread among our patients under this study, we found that (65.6%) of them were suffering from painful conditions distributed at different areas of the face and the neck. Some of those pains were located at the temporomandibular joint region, and perhaps the pain radiated from that area into other places, or from surrounding areas towards the temporomandibular joint (the ears, back of the ears, the temporal sidesetc). This is agreeable with the study of Pollmann [101], and Robert [108].

Similarly, the percentage reached in our study has matched those of Frohlich 1965, who found that symptoms to have existed in 50% of the patients, as well as the study conducted by Agerberg [4], who found that the symptom existed in 62% of the patients.

The results of our study in respect to pain has been found to be far-removed from the results of Schubert and Frank [114], which indicated that only 35% of the patients were suffering from pain as a symptom.

With regard to the limitation of the mouth opening, we found that a high percentage of patients had clear and noticeable improvement (80%) after six months of treatment. However, the degree of improvement has been relatively different depending on the intensity of the case on one hand, and compliance of the patient with applying the occlusal splint as well as the physical therapy sessions on the other. The study of Balcunias 1987 and Siebert [134], mentioned that the treatment by the occlusal splint may yield for the patients an increase in the mouth opening of 3-8 mm.

At the same time Engelhardt [39] stated that in these cases where the distance of mouth opening is less than 30 mm it might be regarded a clear limitation of mouth opening.

As regards to joint crepitation and clicking, which are regarded the most common symptom among the temporomandibular joint patients, reaching a percentage of 58.9 of patients, which is in conformity with other studies Engelhardt [39], Sheppard a. Sheppard [127] although this symptom is considered to be one of the difficult-to-treat cases, since several studies stopped short of achieving any remarkable high percentage improvement.

4.4. Success of treatment

We applied a unified treatment scheme to all groups, each consisting of 30 patients. The program used differed only in terms of the thickness of the splint, with a similarity for all other aspects of medical and physical treatment as well as muscle exercises and treatment by warm water depending of course upon the type of medication used. The rate of success of the treatment with elimination of most of the symptoms, especially the pain and mouth movement limitation reached 76.7%.

This percentage corresponds to other percentages observed in international studies, where the rate of success ranged between 70 and 80%, Agerberg [5] and Carlsson [23].

It is worth noting that this program relied on the standards laid out by Tore Hanson [61] –Willen Honee, Jules Hesse [61].

Percentage of people who did not improve at all came to 23.3%, at a time when there were no rates indicating any retreat or worsening of conditions of suffering patients. This also matches the results offered by De Boever a Schulte [120]. The most resistant aspect of treatment was the clicking or crepitation sounds of the joint. The study showed that it was a symptom that had been difficult to control. Clicking disappeared after treatment in 21.6% of patients, which is a small percentage compared to the rate of pain relief, although we were hoping in our study to overcome the problem mentioned by Forsell Carlson [23], and Pedersen [98,99] regarding treatment of the cracking sound and other joint sounds.

Contrary to previous attempts, the treatment achieved a clear success in terms of augmenting the mouth opening, where improvement rate reached 80% in all patients, conforming to what was mentioned by Mejersjo u. Carlsson [85].

Percentage of patients for whom treatment yielded absolute success i.e. full recovery was 48.9%. 23.3% of the patients did not get any kind of improvement, therefore, we preferred to follow up their treatment and increasing the treatment up to more than 6 months.

4.5. Effective elements for success of treatment: Patient's adherence to applying the splint and its relation to thickness.

In conservative treatment, patient's observance of implementing the treatment plan laid out by the doctor for any given specialty is considered the most vital factor for the success of the treatment.

The occlusal splint used in the disorders of temporomandibular joint constitutes the greater part in the conservative treatment plan. It especially involves wearing the splint almost for the entire day, except for meal times. This means that patient's adherence to apply the splint is crucial for the success of the treatment plan.

Prior to starting our study and upon examination of some patients who were still suffering from pain and disorders in the area of the temporomandibular joint in spite of applying conservative treatment for prolonged periods at other centers or clinics, those patients indirectly expressed their noncompliance or desire in applying the occlusal splint as part of the treatment. Moreover, when they were asked about the reasons, they often said that the splint was so thick that it impeded the articulated speech or was responsible for causing certain aesthetic problems, which led to social and speech disorders, and at time psychological problems. That caused them to refrain from wearing the splint, except at night. Some patients expressed the desire that the splint should be thinner in order that it became more acceptable and less inconvenient to them. Having looked at previous studies, we could not find any specific thickness for the occlusion splint that might be adopted. Some indicated that the thickness should be between (1-4mm). In addition, in our study three dimensions were proposed for reaching a thickness that was likely to be less inconvenient to the patient and more satisfactory in terms of achieving results that would improve the condition of the patient.

4.5.1. Patients adherence to the splint

The first group (1.5mm): 86.6%

The second group (2.5mm): 80%

The third group (3.5mm): 50%

This means that the increase of the thickness of splint depends on the lack of its application by the patient.

4.5.2. Progress of symptoms and recovery

A- Pain, limitation of mouth opening and the clicking sounds:

We noticed that patients' observance plays an important role in the relief of the major symptoms (pain- mouth movement- cracking sound). This is because the rates of disappearance of symptoms in groups 1 and 2 are higher than the rate in the third group.

On comparing the first and the second group, we found that the increase of the thickness of the splint yields better results in terms of elimination of symptoms and subsequent recovery. However, exaggeration with respect of its thickness and getting down to 3.5mm length-wise is likely to lead to noncompliance by the patient of application of the splint. This will adversely reflect on the level of the symptoms.

B- Muscle cramps, bruxism and parafunctions

We noticed that the compliance of the patient plays an important part as far as disappearance of secondary symptoms is concerned (muscle cramps, bruxism and parafunction). This is evident in that the rates of elimination of the symptoms in both first and second groups are far higher than the third group.

Here one may say that although the treatment of muscular contraction and parafunction depends mainly upon physical and psychological treatment as well as on patient's awareness, rather on application of the occlusion splint. The recovery from these symptoms greatly depends upon the extent of the adherence to the whole treatment.

This can be explained in that adherence to part of the treatment scheme would often cause the patient to comply with all aspects of the scheme, and subsequently his observance of the doctor's instructions which contribute to rectify the bad habits responsible for the parafunction with the patient on one

hand, and adherence to physical treatment sessions leading to disappearance of the muscular contraction on the other.

4.5.3. Success of treatment in general

Comparing the results of treatment success in all three groups, we find the following:

Group	Absolute success	Relative success
First group (1.5mm):	23.3%	53.3%
Second group (2.5mm):	30%	63.5%
Third group (3.5mm):	30%	30%

We find that the best percentage of success had been at the patients of the second group, which can be justified in that the thickness of 2.5mm can ensure compliance on the part of the patient as far as application of the splint is concerned, and a greater retreat of symptoms than what we see at first and second groups. Thickness of 1.5mm is more acceptable in patients from both aesthetic and speech points of view, due to being less in height. However, this thickness does not achieve symptom-wise any satisfactory retreat.

The 3.5mm thick splints are less acceptable in patients from the aesthetic and speech points of view, which leads to noncompliance with regard to application as part of the treatment. Consequently, they yield unsatisfactory results in terms of symptoms.

4.6. Period of treatment

- Some studies have shown that the success of treatment has been several weeks. Hansen [59].
- Other studies Carlsson [23]: The study lasted from several months to one year. We have followed the same time span in our present study.
- In certain research, treatment lasted one year and perhaps longer Mejersjö and Carlsson [85].
- Jäger [74] mentioned that absence of improvement in symptoms after years of treatment meant that the condition would not be subject to improvement.

5. Conclusion

In a serious attempt to decrease the rate of failure of treatment of disorders of the temporomandibular joint and orofacial pains, there was a need to look for the factors that cause failure. Judged by the factors discussed, it becomes evident that compliance with use of the splint is a significant factor, and it may perhaps be rated as the most important element in the success of the treatment. Having looked into the reasons for compliance and noncompliance, there have been several reasons, including the health awareness in patients and the educational and social standards of such patients.

In most cases, treatment of such health aware and educated patients have faced failures. Having enquired from many of them, they answered, “The occlusal splint causes social and speech problems to us”

What is the thickness of the splint, which may be acceptable to the patient from both social and speech points of view and that, is likely to achieve for him the best results at the level of clearing the symptoms?

The comparison made between the three dimensions: 1.5mm, 2.5mm and 3.5mm with regard to the applied splint to three groups have drawn a study.

We found that the 1.5mm thickness was the most favorable among patients who strictly adhered to its application. Nonetheless, that thickness did not yield great success at the level of regression of the symptoms. The 3.5mm thickness, on the other hand, was least comfortable for patients, where they failed to adhere to its application and did not leave any chance to the symptoms to retreat and recover, although these symptoms had retreated very satisfactorily in patients who complied with its use in a short span of time.

The 2.5mm thickness was acceptable to patients and yielded higher rates of success at the level of retreat of symptoms.

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Finally, I hope that this study will contribute to surer diagnosis and successful treatment.

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