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Temporomandibular Joint Symptoms Related to Prosthodontic Patient

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By:
Amina Sabri AbdulAima

Supervised by
Assist. Lec. Moamin Ibrahim Issa
B.D.S., M.Sc.

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بسم الله الرحمن الرحيم

نَرفَعُ دَرَجاتٍ مَن نَشَآءُ

وَفَوقَ كُلِّ ذِي عِلمٍ

عَلِيمٌ

صدق الله العظيم

CERTIFICATION OF THE SUPERVISOR

I certify that this project entitled "**TMJ symptoms related to prosthodontic patient**" was prepared by the fifth-year student **Amina Sabri AbdulAima** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

Signature

Assist. lec. Moamin Ibrahim Issa

B.D.S., M.Sc.

(Supervisor)

DEDICATION

I dedicate this research to my family who have always believed in me and supported me throughout my life. Also, my friends for being there for me.

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First and lastly, all gratefulness, faithfulness and thankfulness to ALLAH for providing me with patience, perseverance and the ability to undertake and finally complete this study.

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LIST OF ABBREVIATION

TMJ	Temporomandibular joint
TMD	Temporomandibular disorder
SML	Sphenomandibular ligament
HA	Hyaluronic acid
OA	Osteoarthritis
OVD	Occlusal vertical dimension
CR	Centric relation
SB	Sleep bruxism
AB	Awake bruxism
RCP	Retruded contact position
ICP	Intercuspal contact position
FAO	Functional angle of occlusion
MPD	Muscle pain disorder

INTRODUCTION

Temporomandibular disorder (TMD) is a collective term used for structural and functional disorder associated with the temporomandibular joints, muscles of mastication or both **(McNeill, 1997).**

These are also known as temporomandibular pain dysfunction disorders. TMDs are a group of joint and muscle disorder in the orofacial region characterized mainly by facial pain, pain or muscle tenderness on palpation, pain during jaw movements, reduction of the mandibular movements, headache and abnormal joint sounds **(Pereira *et al.*, 2005, Wright, 2005).**

The pain associated with TMD cannot be defined to be of neurogenic, psychogenic, visceral, periodontal, dental or cutaneous origin. Various epidemiological prevalence studies have shown that up to 40-75% of the general population may experience at least one TMD sign, such as TMJ noise, and 33%, at least one symptom, facial or TMJ pain **(Carrara *et al*. 2010).**

However, only 3-7% reported to seek treatment, with the majority of those who sought treatment being young adults and middle-aged individuals, ranging from 20 to 45 years old particularly females **(Manfredini, 2010).**

The etiology of TMD is considered to multifactorial and till date, no clear conclusion has been reached upon about what variables contribute to the development of TMD. Edentulous subjects generally don’t present with TMD symptoms to the extent of those having natural dentition **(Shetty, 2010).**

TMD appears to be prevalent in complete denture wearers in almost the same proportion as in dentate individuals, with the prevalence varying from 15-25%. Few others have reported that the complete denture wearers were found to have a higher prevalence of TMD symptoms than the population with natural dentition **(Al-Shumailan and Al-Manaseer, 2010).**

The lack of complete dentures for long periods promotes a shift in the vertical and horizontal mandibular position; as a result the position of the condyles in the mandibular fossae may also change. Change of the rest position due to the reduction of the occlusal vertical dimension is also considered to be one of the predisposing factors. Along with this psychological and emotional factors associated with increased age and loss of natural dentition may lead to increased TMDs in edentulous patients **(Shet *et al.* 2013)**

It has been reported that clicking, locking and interarticular disc displacement have been found in patients wearing over-contoured crowns or restorations with excessive occlusal curvatures **(Bengt, 1996).**

It has been reported that prosthodontic replacement of missing teeth may create an acute morphological change of occlusal conditions which consequently may interfere with the established functional equilibrium and timing of jaw muscles contraction **(Hagag *et al.* 2000).**

In general, chewing performance of edentulous individuals wearing complete dentures is significantly less than dentate individuals **(Van der Bilt *et al.* 2010).**

Furthermore, complete denture wearers experienced more difficulty in chewing hard food than dentate subjects and thus a group of subjects with intact dentition had a greater masticatory performance index value **(Wayler and Chauncy, 1983).**

By contrast, it was reported that chewing ability in subjects with cross-arch fixed partial dentures was almost as good as in subjects with complete, healthy dentition and superior to those with complete dentures **(Laurel and Lundgren, 1985).** In addition the masticatory performance, the number of chewing strokes and chewing time until swallowing were similar with removable and fixed partial dentures **(Nagaswa and Tsuru, 1973).**

AIM OF THE REVIEW

To have an overview on the TMD and pathophysiology and their possible causes and different ways of management.

REVIEW OF THE LITERATURE

1.1 Temporomandibular joint anatomy

TMJ is a diarthrosis, it composed of a synovial cavity, articular cartilage and a capsule that covers the same joint. The joint is the union of the temporal bone cavity with the mandibular condyle **(Bender *et al.* 2018).**

TMJ is a freely movable articulation between the mandibular condyle and the glenoid fossa. The condyle articulates against the disk, forming the disk-condyle complex, which articulates with the temporal bone. In comparison with other body articulations, this joint has a unique features. First, functionally the TMJ is a bilateral joint, the right and left joint always functions together. Second, movements of the TMJ are characterized by rotation (between condyle and disk) and translation of the condyle-disk assembly. Third, the articular surfaces of condyle and fossa aren't covered by hyaline cartilage but by fibrocartilage that is stiffer in tension and softer in compression than the hyaline cartilage. Fourth, condylar movements are controlled not only by the shape of the articulating surfaces and the contraction of the muscles but also by the dentition **(Almarza and Athanasiou, 2004).**

1.1.1 Temporal component

It consists of the convex articular tubercle or eminence and the concave glenoid fossa, dorsally limited by the postglenoid tubercle (figure1-1). This lies immediately anterior to the saquamotympanic and petrotympanic fissures. In newborn, the glenoid fossa is very sallow. At age of 5 the growth slows; it stops by the middle to late teens **(Nickel *et al.* 1988,1997).** Attempts have been made to correlate the inclination of the posterior slope with the occlusal characteristics (the inclination of the incisal guidance). However, experimental data support the hypothesis that the steepness of the initial part of the eminence is consistent with the principle of joint load minimization, thus reducing the risk of cartilage fatigue **(Iwasaki *et al.* 2003; Iwasaki *et al.* 2010).**

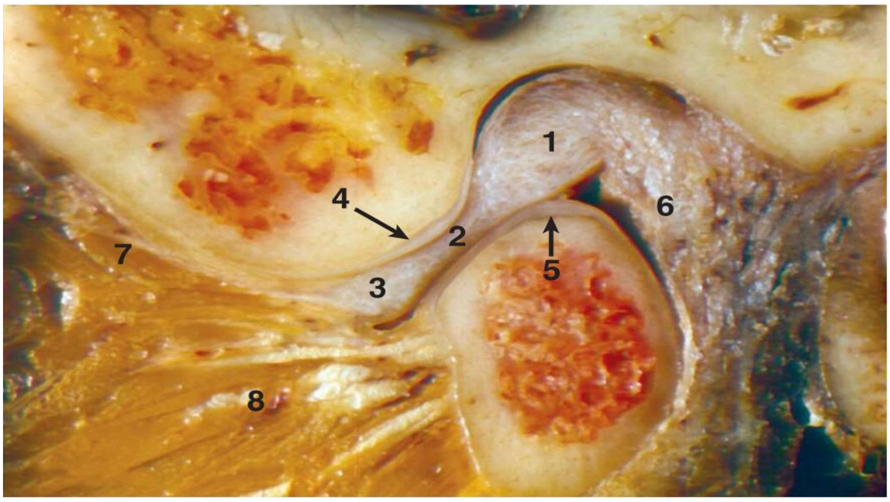


Figure (1-1): Section through TM Joint. (Adopted from (**Lauder and Bobst, 1991).**

1.1.2 Mandibular condyle

The condyle normally has an elliptical shape and measures on average 20mm mediolaterally and 10mm anteroposterior. The dimension and shape of the condyle present great interindividual variations that may be relevant as far as biomechanical loading. The condyle is covered by a thin layer of fibrocartilage that is thickest superiorly and anteriorly, which are the areas loaded under function and parafunction. The fibrocartilage differs in many aspects from the hyaline cartilage, including embryonic origin, ontogenetic development, postnatal growth pattern and histological structures **(Shen and Darendeliler, 2005).**

1.1.3 Articular disk

This fibrocartilaginous avascular and non-innervated structure can be subdivided into an anterior, an intermediate (thinnest) and posterior part. The anterior and posterior zones are called the anterior and posterior bands. The disk is composed of densely organized collagen fibers, high molecular weight proteoglycans, elastic fibers and cells that vary from fibrocytes to chondrocytes. The collagen consists mainly of type I and II. Type II collagen is present especially in areas with proteoglycans, which are found predominantly in the posterior band. The collagen fibers have a typical pattern distribution: in the intermediate zone the thick collagen bundles are oriented sagittaly and parallel to the disk surface. The majority of these fibers continue into the anterior and posterior bands to become interlaced or continuous with the transversally and vertically oriented collagen fibers of these bands or pass through the entire bands to continue into the anterior and posterior disk attachments.

The vertically oriented fibers are more pronounced in the anterior and posterior band. In the intermediate part there is a weaker crosslinking of the collagen bundles, making this area less resistant to mediolateral shear stress **(Scapino *et al.* 2006).**

1.1.4 Joint capsule

Unlike other joints, the TMJ does not have a circular capsule. A distinct capsule connecting the temporal bone to the mandible exist only laterally, posteriorly, medially and anteriorly it is absent or so thin that it can hardly be distinguished from the disk attachments. The lateral capsule, into which the disk transverse fibers insert, is stronger in the anterior and central parts than in the posterior. This strengthened area forms the lateral ligament **(Schmolke, 1994).** Posteriorly, the capsule that made up mainly of condensed fibrous tissue extends from the anterior slope of the postglenoid tubercle to the condylar neck below the attachment of the lower lamina of the posterior disk attachment **(Luder and Bobst 1991).**

1.1.5 Ligamentous structures:

Several ligaments manage the TMJ forces and send multiple proprioceptive afferents. The proprioception of the joint is provided by various components, such as the capsule, masticatory muscles, skin receptors and receptors within the periodontal ligaments. The tension received by the articular ligaments plays an important role in the TMJ function **(Cuccia and Caradonna, 2011).**

1. Sphenomandibular ligament (SML) is a Meckel cartilage residue. Its main task to protect the TMJ from an excessive translation of the condyle after 10 degrees of mouth opening.
2. Stylomandibular ligament (STML) arises from the styloid process of the temporal bone. It serves to limit the excessive protrusion of the jaw.
3. Pterygomandibular ligament (PTML) is a thickening of the buccopharyngeal fascia. It limits excessive jaw movements.
4. Collateral ligament consists of two bundles of symmetrical fibers. It serves to anchor the disk to the condyle.

(Bravetti *et al.* 2004).

1.1.6 Joint lubrication

The functional coefficient within a joint is very low **(Nickel and McLachlan, 1994)**. Impairment of joint lubrication is a risk factor for TMJ osteoarthritis. The articular cartilage is an efficient, fluid-based tribiological system that provides low friction and protects from wear. Optimal lubrication is provided by several mechanism: fluid film, weeping and boundary lubrication. Hyaluronic acid (HA) and proteoglycan 4 are two major lubricants involved in boundary lubrication. Proteoglycan 4, also known as lubricin or superficial zone protein binds to HA to form a cross-linked HA-lubricin complex that is anchored to the cartilage surface by the lubricin itself. As this binding appears to be susceptible to high shear forces, it has been hypothesized that during compression the HA molecules diffusing out of the cartilage into the joint space are mechanically trapped, thus stabilizing the HA-lubricin complex. **(Green, 2011).**

1.1.7 Muscles that provide action to the TMJ

1. Masseter
2. Temporalis
3. Lateral pterygoid
4. Medial pterygoid
5. Suprahyoid
6. Infrahyoid

1.1.7.1 Masseter muscle

The most common muscle of the of mastication. It is the most superficial one and the strongest. This muscle is a broad, thick, flat rectangular muscle, on each side of the face anterior to the parotid salivary gland. It has two heads; deep and superficial. The action of this muscle during bilateral contraction of the entire muscle is to elevate the mandible during closing of the jaw. **(Margaret and Susan, 2012)**

1.1.7.2 Temporalis muscle

It has a very wide origin from the entire temporal fossa and the fascia covering the muscle. All fibers (anterior and posterior) insert into the coronoid process of the mandible and sometimes run down the anterior border of the ramus as far as the third molar. If the entire muscle contracts, the overall action pulls up the coronoid process and elevate the mandible during the mouth closing. If only the posterior fibers are contracted, the result is a horizontal pulling of the coronoid process in the posterior direction, this pulls the mandible backward (retruding of the mandible). **(Richard *et al.* 2019).**

1.1.7.3 Lateral pterygoid muscle:

It consists of an upper head and a lower head. The upper bundle originates from the extracranial face of the large sphenoid wing to be inserted anteromedially to the joint capsule and/or the anteromedial face of the condyle neck. It contacts the disc at the anteromedial aspect. The inferior head originates from the lateral aspect of the lateral lamina of the pterygoid process of the sphenoid. Bilateral activation of this muscle protrudes the mandible while if activated unilaterally, causes contralateral deviation of the mandibular bone**. (Bravettiet *et al*. 2004).**

1.1.7.4 Medial pterygoid muscle:

It is a deep muscle and similar in its rectangular form to the more superficial masseter muscle. It also has two heads; deep and superficial. The action of this muscle is to elevate the mandible, raising the lower jaw during closing of the mouth. The medial pterygoid muscle parallels the action of masseter one, but the effect is smaller overall. **(Margret and Susan, 2016).**

1.1.7.5 Suprahyoid muscle

a. Digastric muscle

It consists of two bellies, the posterior and anterior belly. The parotid gland is related to the posteriolateral aspect of the posterior belly. Its action is to depress the mandible and elevate the hyoid bone **(Parvis *et al*. 2011)** Figure (1-2, A and B).

b. Stylohyoid muscle

Its origin is from the styloid process of the base of the skull. The muscle runs down and forward to insert into the posterior part of the hyoid bone. The action of the muscle is to pull the hyoid bone back and up. **(Richard *et al*. 2019).** Figure (1-2,A and B).

C. Mylohyoid muscle

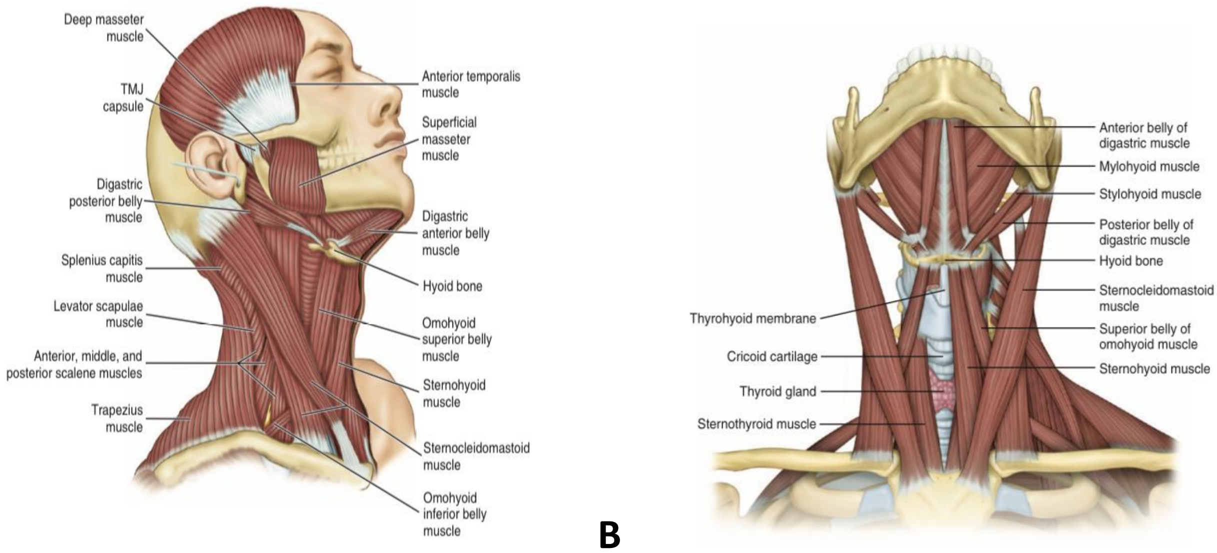
It is an anterior suprahyoid muscle deep to the digastric muscle with fibers running transversely between the two mandibular rami. Its action in addition to either elevating the hyoid bone or depressing the mandible, it also form the floor of the mouth and helps to elevate the tongue. **(Margret and Susan, 2016)** Figure (1-2,A and B).

d. Geniohyoid muscle

It is originated from the inferior genial tubercle and inserted in the hyoid bone. Its action is to depress the mandible and elevate the hyoid. **(Richard *et al*. 2019).**

1.1.7.6 Infrahyoid muscle

They are made up of omohyoid, sternohyoid and thyrohyoid muscles. when they contract, they depress the hyoid bone, allowing the suprahyoid muscles to contract and depress the mandible. **(Samuel, 2021).** Figure (1-2, A and B).



A **B**

Figure (1-2): (A) lateral view of the head and neck muscles. (Adopted from **(Nelson and Ash, 2010)**. (B) anterior view. (Adopted from **(Fonseca et al. 2013).**

1.2 Mandibular movements:

1. Depression (jaw opening)
2. Elevation (jaw closing)
3. Protrusion
4. Retrusion
5. Lateral deviation

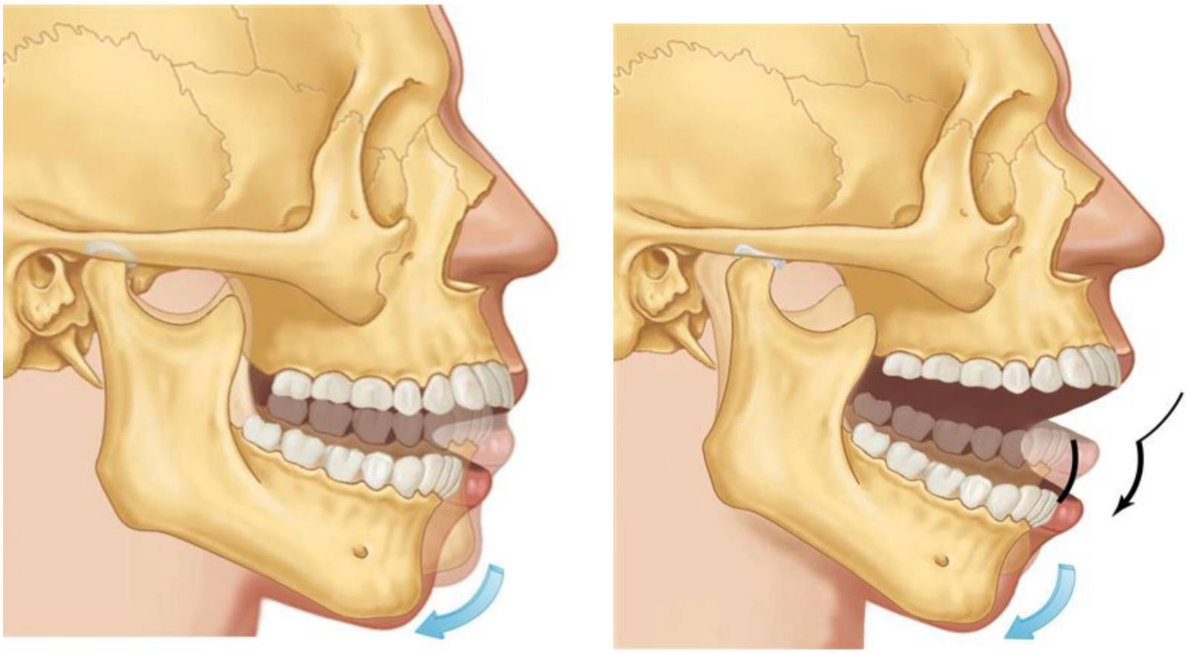
1.2.1 Rotation versus translation

Condylar rotation and translation of the condyle-disk assembly, in the majority of cases, begin simultaneously. On average, condylar rotation increases or decreases linearly by approximately 2mm of anterior or posterior translation during opening or closing. **(Salaorni and Palla 1994)** Figure (1-3) and figure (1-4).

However, there is great intraindividual and inetrindivdual variability: three patterns have been described during jaw opening and four during jaw closing. On opening, movements are usually performed by constant increase in rotation and anterior translation, less often by marked rotation at the beginning of opening, and less frequently by a marked initial and final rotatory movement. closing movement show a greater variability between rotation and translation. **(Salaroni and Palla 1994).**

The amount of condylar rotation does not differ between males and females, a finding which contrasts with the larger maximum interincisal opening of men compared to women due to differences in the mandibular length. **(Naeije, 2002).**

Indeed, with the same degree of rotation, the larger the mandible, the larger the mouth opening. Consequently, the degree of interincisal opening cannot be considered as a measure of joint mobility or laxity, unless it is corrected for mandibular size.



A **B**

Figure (1-3): (A), Rotational movement about a fixed point in the condyle. (B), Second stage of rotational movement during mouth opening. (Adopted from **(Muraoka *et al*. 2021).**

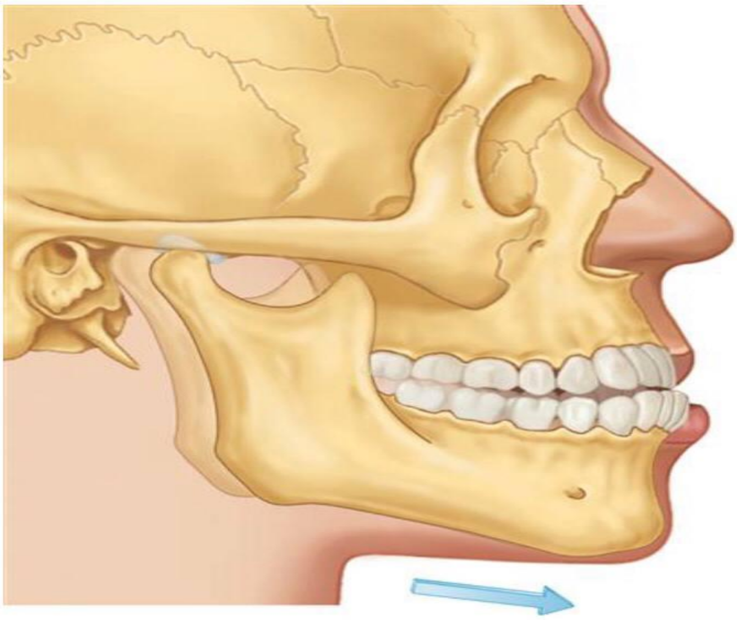


Figure (1-4): Translational movement of the mandible. (Adopted from **(Muraoka *et al.* 2021).**

1.1.8 Joint innervation

The TMJ capsule and synovia are richly innervated by branches of the trigeminal nerve: the auriculotemporal, masseteric, and deep posterior temporal nerves. Small nerve bundles also innervate the most peripheral parts of the disk, especially the anterior an posterior bands. **(Asaki et al. 2006, Haeuchi et al. 1999, Morani et al. 1994, Yoshida et al. 1999).** The auriculotemporal nerve provides the main innervation source so that it is sufficient to block this nerve when the TMJ must be anesthetized (to diagnose whether the pain is arthrogeneous or myogeneous). The TMJ receives inputs from a variety of ganglia, the major contribution being provided by the trigeminal and superior cervical ganglia. Minor contributions come from the sphenopalatine, otic, nodose and cervical dorsal root ganglia at levels C2-C5. **(Uddman et al. 1998, Yoshino et al. 1998).**

1.1.9 Joint blood supply

The main blood supply to the TMJ is by:

1. Branches of the superficial temporal
2. Deep auricular
3. Anterior tympanic
4. Ascending pharyngeal arteries

They penetrate the joint capsules and provide branches to the disc periphery and posterior joint region. A rich plexus of veins is present in the posterior aspect associated with the retrodiscal tissues. **(Bordoni and Varacallo, 2020, Chandra, 2010).**

1.2.2 Condylar movement

Mandibular movement occur by a combination of translation of the condyle-disk assembly and rotation of the condyle beneath the disk.

It is likely that the movement between disk and condyle is not always purely rotator, as dynamic MRI shows that the condylar translation precedes disk translation. This is always case with disk translation.

Translation between disk and condyle may reflect some laxity of the disk ligaments and could be a first sign of an incipient disk displacement.

(Figure 1-5) shows a lateral view of the movement of the condyles during closing the mandible in the chewing cycle.

The first image represents the position at the beginning of the closing. Three features may be appreciated. First, there is a difference in timing between movement of both condyles, the working condyle reaches its uppermost position before the nonworking one. In the fourth image, the working condyle is almost seated in the fossa, while the nonworking one is still in the eminence posterior slope. This lead to the hypothesis that the working condyle acts as a stabilizing fulcrum during the 'power stroke' which is when force applied to crush food.

Second, during opening, both condyle translate approximately the same amount and are located behind the eminence.

Third, as seen in the sixth image, the condyle rotates by 10 degree, far less than during the maximum opening when it rotates on average by 30 degree

During so small rotation, only the superior part of the condyle is loaded, and this is the area where the fibrocartilage is thickest**. (Salaorni and Palla, 1994).**

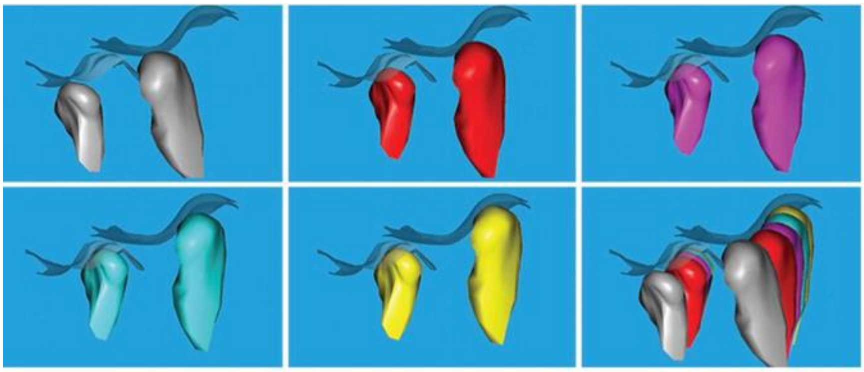


Figure (1-5): Five positions of the ipsilateral and contralateral condyle during the closing phase. (Adopted from **(Sandro and Iven, 2015).**

1.2 Joint loading

A query often raised in dentistry is whether or not the TMJ is loaded during function. The measurement of the minimum condyle-fossa distance by means of dynamic sterometry provides an indirect technique to answer this question. During chewing the minimum condyle-fossa distance was observed to be smaller during the closing than the opening phase, and the decrease was larger on the nonworking than on the working side **(Fushima *et al*. 2003, Palla *et al*. 1997)**. This is indirect evidence that the TM joint is loaded during chewing, more on the nonworking than on the working side.

Given the incongruence of the articulating surfaces, the stress applied to the TMJ is principally controlled by the disk. Its inherent rheological properties allow its adaptation to the incongruence of the articulating surfaces so that the comprehensive stress is distributed over a larger contact area, reducing the risk of peak**.** The disk compressive module depends on proteoglycan density and therefore varies in different disk regions **(Tanka and van Eijden 2003).**

Moreover, the disk thickness determines the disk load bearing capacity; the thinner the disk the more concentrated and intensive the loading of the articular surfaces **(Nickel and McLachlan, 1994)**

Although thinner than the disk, the cartilage covering condyle and fossa also contributes to absorbing the compressive stress, at maximum intercuspation, the condyle lies behind the disk, whereas at maximum opening it is normally positioned below the disk **(Hansson and Oberg, 1977).**

(Kuroda *et al*. 2009; Lu *et al*. 2009). Interestingly, the cartilage of the apex and posterior slope of the eminence, can increase in thickness when the disk is anteriorly displaced, as an adaptation process to the altered stress.

Mechanical loading during movements is essential for growth is essential for growth, development, and maintenance of the articular tissue because mechanical forces maintain cartilage health by regulating tissue remodeling **(Jonsson *et al.* 1999).**

1.4 Temporomandibular joint pathophysiology

1.4.1 Disk displacement

In about one third of subjects without symptoms of TMD, the disk is displaced anteromedially or anterolaterally.

The etiology of disk displacement is not fully understood. Several risk factors have been suggested, **anatomical factors**, for example, large incongruence between condyle and fossa dimensions, a steep and high eminence and a posterior condylar position, **biomechanical factors**, for example overloading of the TMJ by parafunctional habits, changes in joint lubrication that may lead to gradual increase stretching of the lateral disk attachments and disk instability **(Naeije, 2002)**.

Wake time parafunctions may be a risk factor for the progression of an intermittently non reducing to a continuously non reducing disk displacement, and this could be related to joint loading **(Kalaykaova *et al*. 2011)**.

However, non of these factors is undisputed.

The way the disk is loaded changes when the disk is displaced, essentially there are increased compressive and tangential stresses in the posterior band, due to the condyle pushing and compressing it against the fossa, and a reduced compressive stress in the intermediate and anterior disk zone, the decrease depending on the degree of displacement (partial, total, with displacement or without displacement).

In addition the medial, lateral and anterior disk attachments undergo a higher degree of tensile stress **(del Palomar and Doblare, 2007)**.

Inevitably, these load changes cause tissue remodeling that may continue to disk degeneration. For instance, the posterior attachment that is interposed between the condyle and fossa undergoes fibrotic changes: the collagen fiber bundles become thicker, more rectilinear, and oriented parallel to the attachment surface, the elastic fibers thin out and the vascularity decreases. In addition, the fibrotic attachment may appear hyalinized and contain cells of cartilage phenotype and proteoglycans.

In the posterior band, the collagen fibers become aligned in all directions and the transverse bundles increase in thickness, probably to resist the increased tensile stress in the mediolateral direction **(Scapino and Mills, 1997, Lunder, 1993).**

An anteriorly displaced disk presents hostological alterations typical of degeneration that are more pronounced in non-reducing than reducing disks, increase of chondrocyte like cells and decrease in fibroblast like cells, hyalinization, alteration of the fiber bundles, clefting and fraying. **(Natiella *et al.* 2009; Leonardi *et al*. 2010; Loreto *et al*. 2011).**

1.4.2 Osteoarthritis

TMJ is a synovial joint that performs the most complicated movement in the human body. OA is a degenerative disease that is characterized by progressive cartilage degradation, subchondral bone remodeling, synovitis, and chronic pain. However, the etiology of the majority TMJ osteoarthritis is complex and multifactorial or unknown. It is also an important subtype of TMDs. **(Zarb and Carlsson, 1999).** It is secondary to disk displacement, trauma, functional overload, and developmental abnormalities, such as secondary TMJ osteoarthritis **(Tanaka *et al*. 2008).**

Researches in the last decades led to several shifts. First, while in the past OA was considered non inflammatory, there is today considerable evidence that inflammation is involved: the synovial fluid of OA joints contains inflammatory cytokines, chemokines and other inflammatory mediators that are produced by chondrocytes and synovial cells by early phase. **(Goldring and Otero, 2011; Sokolove and Lepus, 2013).**

As a result, the term "osteoarthritis" instead of "degenerative joint disease" as used in the diagnostic criteria for TMD (temporomandibular disorder).

(Schiffman *et al*. 2014).

Second, because of its complex etiology, OA is not considered now as a single entity but the endpoint of numerous disorders with pathological changes sharing a common final pathway that leads to joint destruction. **(Sokolove and Lupus, 2013).**

Third, OA is not a cartilage disorder but a disease of the whole joint, including the subchondral bone, the synovial membrane, the ligaments and the muscles. **(Brandt *et al*. 2006).**

Fourth, changes in the subchondral and periarticular bone may occur early in the course of OA, leading to an imbalance between the higher load adaptive capacity of the bone over that of the cartilage. This imbalance alters the physiological relationship between these tissues, leading to development of OA **(Goldring and Goldring, 2010).**

1.5 Parafunctional problems

Many studies have found that bruxism or other parafunctions are associated with TMD and orofacial pain **(Manfredini and Lobbezoo, 2010).**

1.5.1 Bruxism

Is a masticatory muscle hyperactivity that can occur while the person is asleep or awake. It is defined as "an excessive activity of the chewing muscles, characterized by clenching or grinding the teeth and/or by the recurrent excessive effort made by the jaw" **(Lobbezo, *et al*. 2013).**

The masticatory mascular activity of the patient according to the moment in which it is performed: sleep bruxism (SB) or awake bruxism (AB); this highlighting the need to separate the terms, since bruxism is generated in two moments therefore different signs, symptoms and characteristics will appear.

Additionally, it must keep in mind that the bruxism is not considered a disorder rather a behavior because its effects do not necessarily produce damage.

The physiological predisposing factors of bruxism cannot be individualized, since this is the result of a combination of causes which produce a pathogenic, repetitive and often unconscious action. In adult patients, possible casual factors have been reported such as: occlusal forces, emotional causes or those generated by the central nervous system. **(Gittelson, 2005).** Psychological problems such as stress and anxiety in all ages; in addition, SB in children is associated with respiratory problems, physiological dental wear, caries, malocclusions and use of pacifiers.

The treatment of bruxism is suggested to be multidisciplinary, for both children and adults. Dental treatment include some intraoral devices, which aim to protect teeth and restorations from possible wear and tear that may be generated as a result of parafunctional activity **(Beddis *et al.* 2018)**. Treatment with physical therapy consists of performing exercises of the masticatory muscles and they should be performed without exerting excessive intensity, since this can generate micro-trauma to the muscle fibers **(Gouw *et al*. 2017).** Likewise, other options of management with cognitive-behavioral therapies including psycho-analysis, autosuggestion, hypnosis, progressive relaxation, medication, and self-control **(Loobezoo *et al*. 2008).**

1.5.2 Clenching

Tooth clenching more than tooth grinding, is considered one of the most detrimental oral parafunctional activities and has been implicated as important factor in the etiology of TMD. This frequent parafunctional behavior is of major concern to the dentists because of its possible consequences on the different components of the stomatognathic system as excessive occlusal forces are able to cause dental restoration or hard tissue breakdown (wear, cracks), periodontal breakdown (mobility) or TMD. **(Ommerborn *et al*. 2010)**. These two activities (bruxism and clenching) are likely to have different consequences on the masticatory muscles and the TMJ and there is some consensus that awake clenching is associated more with jaw pain than sleep grinding **(Huynh *et al*. 2011).** low-level parafunctions in pain free individuals have been shown to produce symptoms sufficiently sever to meet the diagnostic criteria for TMD myofascial pain or/ and arthralgia. **(Chen *et al*. 2007) and (Glaros, 2008).** Prior experience of TMJ noise and jaw muscle discomfort is also more frequent in subjects with clenching awareness **(Katase-Akiyama *et al*. 2009).**

There are different methods for evaluation of tooth clenching, these include laboratory polysomnographic or portable electromyographic (EMG) recordings, questionnaires for self-evaluation (sleeping partners report of grinding sounds during night, self-report of muscle fatigue or pain on awakening), extra-oral and intra-oral eaxaminatons for clinical signs (masseter hypertrophy, pain on palpation of the masticatory muscles, wear facets on teeth or shiny spots on the restorations). Among these methods, polysomnographic recordings provide the most suitable research diagnostic criteria. **(Baba *et al*. 2003), (Ommerborn *et al*. 2010).**

The loads are distributed over the articular surfaces of the TMJ, mainly the disk, which functions as a stress absorber and a stress distributor. An increase in elevator muscle tonus leads to increased intra-articular pressure in the TMJ and alteration in its normal biomechanics resulting in micro-traumatic damage to the joint capsule and disk attachment. **(Gameiro *et al*. 2006).**

1.6 Alteration in the occlusal vertical dimension

The loss of posterior teeth results in the occlusal plane collapsing due to the extraction of the antagonist teeth and lack of the posterior support result in sever wearing of the remaining teeth. When there is insufficient space for prostheses due to excessive wear, prosthetic restoration is necessary at the position where the original vertical dimension needs to be restored. **(Verret,**

2001). From clinical perspective, it is advantageous to consider altering the vertical dimension for restorative material, enhancing the esthetic tooth display and allowing for reestablishment of physiologic occlusion. **(Abduo, 2012).**

the determination of the correct vertical dimension of occlusion for edentulous patients is one of the most important steps for constructing the dentures with adequate esthetics and functions **(Heartwell and Rahn, 1986).**

The position of the condyles does affect muscle length and hence the occlusal vertical dimension (OVD). When looking at changes in vertical dimension (VD) in paramount to the mount study cast in centric relation (CR); when the head of the condyles are in their most superior position within their sockets, with discs properly aligned and full neuromascular release **(Bloom, 2006).**

An increase in the (OVD) beyond postural rest position causes an increase in muscle activity in the jaw-closing muscles as the musculature attempts to recover the individual's original interocclusal clearance. The effect of change of the vertical dimension on the bite force or electromyographic activities of the masticatory muscles has been studied by many investigators.

The results of some of these studies indicate that the maximum biting force is exerted around the rest position **(Manns *et al.* 1979),** while those of the others indicate that it is exerted at greater vertical dimensions of occlusion **(Academy of prosthodontics, 2005).**

The electromyographically recorded postural muscle activity was lower with splints than without them. The increase of OVD thus seems not to induce increase muscle activity to restore the original OVD. The lower postural activity with splints and in the anterior temporalis muscles also lowered the mandibular positions. These were in accordance with the results from many studies demonstrating that lowering the mandible leads to decreased muscle activities **(Lindauer *et al.* 1991).** Increasing the vertical dimension in both subjects with natural teeth and with complete dentures resulted in deranging the function of muscles and joints of the masticatory system, and therefore may be considered to be a hazardous procedure in prosthetic treatment **(Christensen, 1970).**

1.7 Occlusal management of TMJ problems

1.7.1 Occlusal adjustment in occlusal management

Occlusal adjustment is a procedure whereby selected areas of tooth surface, in either dentate or partially dentate patients, are modified to provide improved tooth and jaw stability and direct loading to appropriate teeth during lateral excursion. This may involve tooth surface reduction and tooth surface addition with a restorative material. **(Frossel and Kalso, 2004).** It is apparent when treating a patient with an occlusally balanced appliance that the mandibular position can alter quite markedly as treatment progress and painful muscle relax**.** As an initial therapy, occlusal adjustment is therefore not recommended as jaw and tooth relationships cannot be accurately determined in the presence of pain. It would therefore appear to be sound advice not to make permanent and irreversible adjustment to the occlusion in the presence of TMDs, as when the disc is repositioned occlusal contact will change. **(Tsukiyama *et al*. 2001).**

1.7.1.1 Aims of occlusal adjustment

1. To maintain intra-arch stability by providing an occlusal plane with minimal curvature anteroposteriorly and minimal lateral curve. This minimizes the effect of tooth contact interferences.
2. To maintain inter-arch stability by providing bilateral synchronous contacts on posterior teeth in RCP (retruded contact position) and ICP (intercuspal contact position) at the correct occlusal vertical dimension (OVD). Supporting cusps of posterior teeth are in a stable contact relationship with the opposing fossae or marginal ridges.
3. To provide guidance for lateral and protrusive jaw movements on mesially directed inclines of anterior teeth, or as far anteriorly as possible. Posterior

guiding contacts are modified so as not to be a dominant influence in lateral jaw movements.

4. To allow optimum disk-condyle function along the posterior slope of the eminence, by encouraging smooth translation and rotation of the condyle.
5. To provide freedom of jaw movement anteriorly and laterally. This overcomes a restricted functional angle of occlusion (FAO) caused by inlocked tooth relationships. A restricted FAO arises in the following types of tooth arrangements: deep anterior overbite that is not in harmony with the condylar pathway, undercontoured restorations with loss of OVD, extruded teeth and plunger cusps. **(Forssel and Kalso, 2004).**

1.7.1.2 Indications for occlusal adjustment

1. As a pretreatment in prosthodontics and general restorative care:

a. To improve jaw relationships and provide stable tooth contacts for jaw support in ICP

b. To improve the stability of the individual teeth

2. To enhance function by providing smooth guidance for lateral and protrusive jaw movements. This may involve modification pf plunger cusps, inlocked cuspal inclines and mediotrusive, laterotrusive and protrusive tooth contact interferences.
3. To modify a traumatic occlusion where tooth contact interferences are associated with excessive tooth loading, such as may occur in parafunctional clenching, resulting in tooth sensitivity, abfractions or fractures and/or increased tooth mobility. Occlusal adjustment will direct loading to appropriate teeth in an optimal direction and where possible along their long axes.
4. To stabilize orthodontic, restorative, or prosthodontic treatment. In such cases where it is decided that existing restorations are to be retained, an occlusal

adjustment may be indicated. Alternatively, adjustment in conjunction with occlusal buildup on selected teeth may be required **(Forssell *et al*. 1999).**

1.7.2 Full mouth rehabilitation

The term occlusal rehabilitation has been defined as the restoration of the functional integrity of the dental arches by the use of inlays, crown, bridges and partial dentures. It therefore involves restoring the dentate or partially dentate mouth. The aim is to provide an orderly pattern of the occlusal contact and articulation that will optimize oral function, occlusal stability and esthetic **(Binkely and Binkely, 1987).**

1.7.2.1 Indications of full mouth rehabilitation:

The reasons for undertaken occlusal rehabilitation may include the restoration of multiple teeth, which are missing, worn, broken down or decayed. Increasingly occlusal rehabilitation is also required to replace improperly designed and executed crown and bridge work. Regardless of the clinical reason, the decision to carry out any treatment should be based upon achieving oral health, function, esthetics and comfort with treatment should be planned around these rather than the technical possibilities. If these goals are achieved certain biological considerations are necessary when planning and carrying occlusal rehabilitation. They are:

1. The indications for reorganizing the occlusion
2. The choice of an appropriate occlusal scheme
3. The occlusal vertical dimension
4. The need to replace missing teeth
5. The effects of the material used on occlusal stability control of parafunctional TMD

Several decisions must be made concerning the complex area of occlusion, before starting occlusal rehabilitation. The clinician must be aware of the requirements that a physiologic restoration be made that is not only aesthetic and functional but that also remains in harmony with the entire gnathostomatic system. **(Mandeep *et al.* 2016)**

1.7.2.2 The three-step technique of full mouth rehabilitation:

To achieve maximum preservative of tooth structure and the most predictable esthetic and functional outcomes, an innovative concept has been developed: the three-step technique (Table1-1).

Step 1: Maxillary vestibular waxup and assessment of the occlusal plane

Generally, at the beginning of full mouth rehabilitation, the clinician will provide a laboratory technician with the diagnostic casts and request a full-mouth waxup. Since each parameter, such as incisal edges, teeth axes, teeth shapes and sizes, occlusal plane, etc, is easily controlled, waxing both maxillary and mandibular arches is not a difficult task. Clinicians should realize, however, that laboratory technician will often arbitrarily decide on these parameters without seeing the patient and with a misleading lack of reference points (e.g. adjacent intact teeth). One method to ensure that everyone is on the same page is the use of the mock-up, a technique that makes it possible to anticipate the final shape of the teeth in the mouth. Several authors have already proposed the use of a mockup for veneer restorations of anterior teeth **(Magne and Belser, 2004).**

Step 2: The posterior support (posterior occlusal waxup)

The aim of this step is to waxup the posterior teeth at an increased OVD. This involve only the occlusal surfaces of the two premolars and the first molar, and will be fabricate direct composite restoration by means of transparent key, figure (1-6). After having established esthetic occlusal plane in step 1, in order to complete the occlusal surfaces of the posterior teeth it is necessary to determine the increased OVD. In case of severely worn dentition, an increased OVD is inevitable to reduce the need for substantial tooth preparation in general, and to avoid elective endodontic treatment, in particular in the anterior teeth. Clinicians are generally afraid to increase the OVD, fearing consequence at the level of the TMJ. On the contrary, the capacity to adapt to change of the OVD is generally remarkable **(Abduo, 2012).**

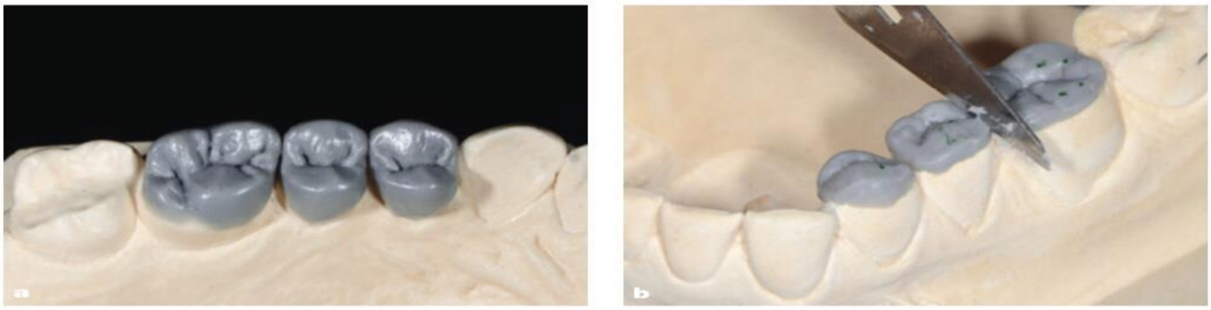


Figure (1-6): The posterior wax-up to fabricate the transparent key. (Adopted from (Francesca and Sylvian, 2016).

Step 3: The anterior contact (reestablishment of the final anterior guidance)

In this step, the laboratory will recreate in wax the palatal surface of the maxillary anterior teeth before fabricating the palatal veneers. The shape of the two central incisors was already proposed with the anterior stop, and confirmed or changed by the clinician. In case the laboratory technician realizes that the clinical increase of the OVD was excessive to reestablish the anterior contacts by means of veneers, he can progress with the fabrication of the final anterior restorations to the shape, which will have no contacts with the antagonistic teeth **(Francesca and Sylvian, 2016).**

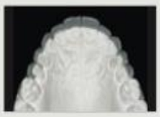
	Laboratory		Clinical	
	Maxillary vestibular waxup	Step 1: Esthetics	Assessment of occlusal plane	
	Posterior occlusal waxup	Step 2: Posterior support	Creation of posterior occlusion at an increased VDO	
	Maxillary anterior palatal onlays	Step 3: Anterior guidance	Reestablishment of final anterior guidance	

Table (1-1): The three-step technique. Adopted from **(Francesca and Christoph, 2008)**

1.7.3 Occlusal splint therapy

This therapy is the art and science of establishing neuromascular harmony in the masticatory system and creating a mechanical disadvantage for the parafunctional forces of the removable appliances. Occlusal appliance therapy is a form of reversible occlusal intervention that temporarily alters the patient's occlusal condition, thereby reducing the joint overload. The occlusal bite appliances are removable devices made up of hard acrylic and have costume fit over the occlusal surfaces of the teeth, figure (1-7). **(Al-Ani *et al.* 2004).** Splints are constructed in a way to achieve bilaterally symmetrical occlusal contact posteriorly with teeth of opposing arch in centric occlusion (flat plane splint) or there may be anterior contacts in lateral and protrusive excursion of the mandible (anterior repositioning splints). Effectiveness of occlusal splint is to decrease loading on the TMJ and reduction of the neuromascular reflex activation. The stabilization appliance is generally fabricated for the maxillary arch. It provides occlusal relationship, considered optimal for the patient and ensure that the condyles are in their most muscuoskeletal position when the teeth are contacted.

It eliminates the orthopedic instability between occlusion and joint position, thus removing the causative factor. **(Clark, 1988)**

Stabilization splints are indicated for the treatment of muscle pain disorder (MPD), TMD that relates to muscle hyperactivity (bruxism), local muscle soreness or chronic centrally mediated myalgia and for patients experiencing retrodiscitis secondary to trauma, the appliance can help minimizing the forces to damaged tissues, thus permiting more efficient healing.

Whereas anterior positioning splint is an interocclusal device that encourage the mandible to assume a position more anterior. Its goals are to provide a better condyle-disc relationship in the fossa. So that the tissues have better opportunity to adapt or repair and would eliminate the signs and symptoms associated with disc derangement disorder. **(Srivastava *et al.*, 2013).**

Table (1-2): Comparison between two types of occlusal splint (Adopted from **(Darpan, 2021)**

Stabilization appliance	Anterior repositioning appliance
Hard acrylic flat-plane device	Hard acrylic device
Full coverage maxillary occlusal arch	Maxillary or mandibular occlusal coverage splint with anterior inclined plane
Worn 24 h/day (-,+ during meals)	During jaw closure, mandible moves anteriorly
Bilateral even distribution of occlusal forces	Usefull for anteriorly displaced disc to change the condylar position and recapture disc
Provides stabilization of the TMJ apparatus	Possible need for occlusal equilibration and splint readjustment
Relaxation of masticatory muscles	

1.7.3.1

1.7.3.2 Function of occlusal appliance:

1 To relax the muscles
2 To allow the condyle to seat in centric relation
3 To provide diagnostic information
4 To protect teeth and associated structures from bruxism
5 To mitigate periodontal ligament proprioception
6 To reduce cellular hypoxia levels

(Al-Ani *et al*. 2004).

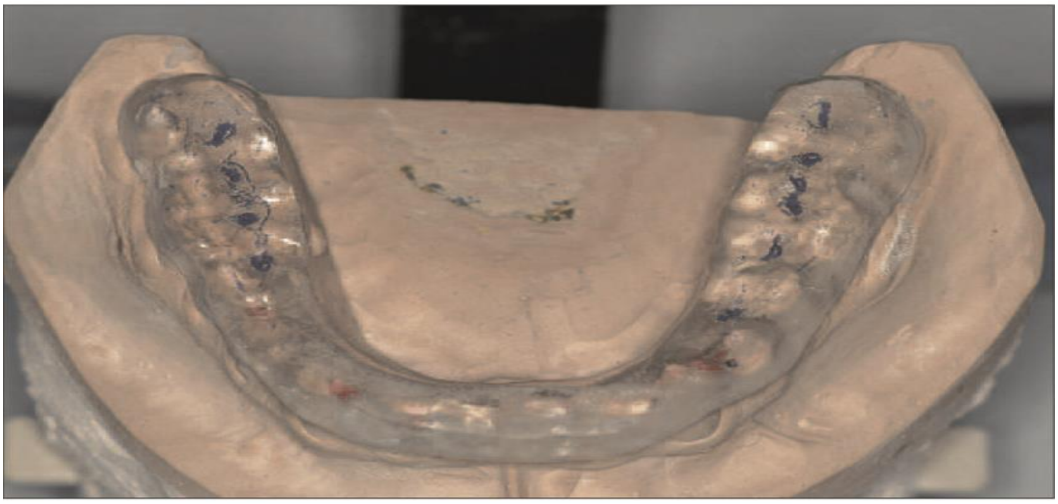


Figure (1-7): The stabilization splint. (Adopted from **(Jean, 2012).**

1.7.3.3 Types of occlusal splint

a. Flat plane stabilization appliance (Michigan splint)

Also known as the gnathologic splint, Michigan splint, or muscle relaxation appliance. This appliance is generally fabricated for the maxillary arch but, for esthetics and avoid interference with a speech, some clinicians have recommended that it could be placed for the mandibular arch. No differences in reduction of symptoms whatever the appliance is placed for the maxilla or mandible, figure (1-8). **(Turp *et al*. 2004).** It is stated that wearing the appliance increases the patient's awareness of jaw habits and helps alter the rest position of the mandible to a more relaxed position. **(De Leeuw and Pain, 2013).**

Figure (1-8): Michigan splint. (Adopted from **(Tomislav *et al*. 2013)**

b. Anterior bite plane (Traditional anterior bite plane)

The origin of anterior bite plane related to orthodontist. In general, these appliances are designed as a palatal-coverage horseshoe shape with an occlusal table covering 6or8 anterior maxillary teeth, figure (1-9). Advocates for using this appliance to treat TMDs based on their ability to prevent clenching, as posterior teeth are not engaged in functional or para-functional activities. However, an adverse effect may occur in the form of overeruption of posterior teeth which extremely unlikely if worn only at night without posterior support of the TMJs will be overloaded **(Klasser and Greene, 2009).**

Figure (1-9): Anterior bite plane appliance. (Adopted from **(Dipikia *et al.* 2019).**

c. Posterior bite plane appliance (mandibular orthopedic repositioning appliance)

These appliances made to be worn on the lower arch. The design consists of a bilateral hard acrylic resin table, creates disocclusion of the anterior teeth, located over the mandibular molars and premolars and connect with a lingual metal bar, figure (1-10). These appliances intended to produce vertical dimension and horizontal maxillomandibular relationship changes. **(Schubert *et al.* 1984).**

Figure (1-10): Posterior bite plane appliance. (Adopted from **(Dipikia *et al*. 2019).**

d. Pivot appliance:

It is fabricated with hard acrylic resin that covers the maxillary and mandibular arch with a single posterior occlusal contact, placed as far posteriorly as possible in each quadrant, figure (1-11). These appliances reduce intra-articular pressure by condylar distraction as the mandible fulcrums around the pivot, resulting in an unloading of the articular surfaces of the joint. The pivoting appliance was suggested for patients with internal derangement or with osteoarthritis. **(Klasser, Greene, 2009).**

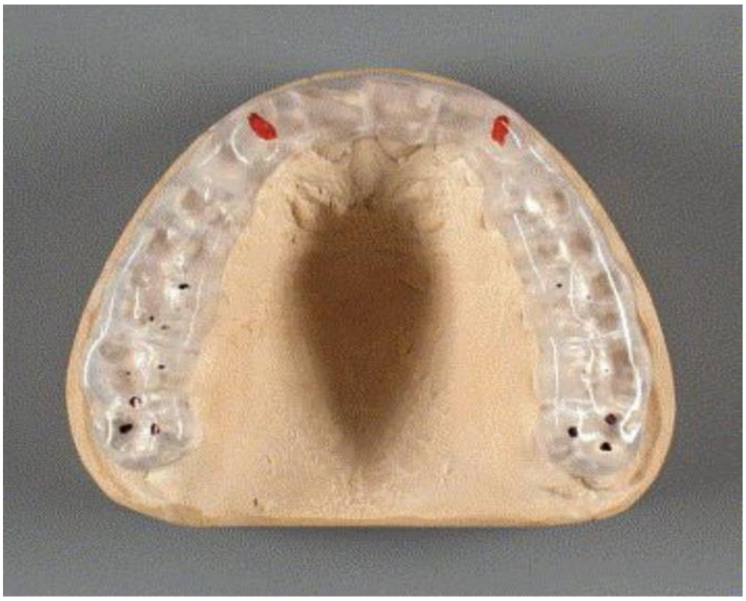


Figure (1-11): Pivot splint. (Adopted from **(Dipikia *et al.* 2019).**

e. Hydrostatic appliance

A bilateral water filled chamber attached to an acrylic palatal appliance, and the patient's posterior teeth occlude with water filled chambers, figure (1-12). It is designed by Lerman, latter on a modified design, retained under the lower lip was suggested. The mode of mechanism of the appliance depends on the concept that the mandible finds its ideal position automatically. **(Alqutaibi *et al.* 2015.)**

Figure (1-12): Hydrostatic splint. (Adopted from **(Dipikia *et al.* 2019).**

f. Soft rubber splint

This appliance is generally made of a resilient material (2 of polyvinyl sheet), figure (1-13). This splint should be worn only at night and generally produces asymptomatic relief within 6 weeks. The soft splint is less likely to cause significant occlusal changes that are occasionally noted with hard occlusal splint. They are used to reduce the symptoms of joint dysfunction or myalgia, to prevent bruxism and clenching and as a protective device in athletes. But these appliances can exacerbate the bruxism probably due to the in ability to achieve balanced occlusal contacts **(Okeson, 1987).**

Figure (1-13): Soft rubber splint. (Adopted from **(Dipikia *et al.* 2019)**

2.1 CONCLUSION

From this study we can conclude:

1. TMD represent a major cause of non-dental pain in the orofacial region, the effects of which may be presumed to form at the site where the greatest forces are exerted and host resistance is least.

2. The OVD is not an optimal vertical dimension that produces the maximum biting forces, and the maximum biting forces obtained at a higher vertical dimension than the vertical dimension of occlusion.

3. Occlusal splints are the most popular TMD treatment modality and the easiest one to fabricate and to manage.

4. The clinician must be aware of the requirements that a physiologic restoration to be made that is not only aesthetic and functional but also remains in harmony with the health of the TMJ and the entire gnathostomatic system.

REFERENCES

(A)

- Abduo, J. (2012). Safety of increasing vertical dimension of occlusion: A systematic review. *Quintessence* Int. 2012, 43, 369–380.
- Academy of Prosthodontics. (2005). The glossary of Prosthodon-tic Terms. J. Prosthet. Dent.; 94 : 11-92.
- Asaki, S., Sekikawa, M., & Kim, Y. T. (2006). Sensory innervation of temporomandibular joint disk. Journal of Orthopaedic Surgery, 14(1), 3-8.
- Al-Ani, M., Davies, S., Gray, R., Sloan, P. and Glenny, A., 2014. Stabilisation splint therapy for temporomandibular pain dysfunction syndrome. Cochrane Database of Systematic Reviews.
- Almarza AJ, Athanasiou KA. (2004). Design characteristics for the tissue engineering of cartilaginous tissues, Ann Biomed Eng 32:2-17.
- Types of occlusal splint in management of temporomandibular disorder (TMD). Journal of arthritis. Alqutaibi and Abdoalrejal, J Arthritis. 2015, page (1-4).
- Al-Shumailan YR, Al-Manaseer WA. (2010). Temporomandibular disorder features in complete denture patients versus patients with natural teeth; A comparative study. Pak Oral Dent J. 30:254–59.

(B)

- Baba K, Clark GT, Watanabe T Ohyama T. (2003). Bruxism force detection by a piezoelectric film -based recording device in sleeping humans. J Orofacial Pain. 2003;17: 58-64.
- Beddis H, Pemberton M, Davies S. (2018). Sleep bruxism: An overview for clinicians. Br Dent J 225: 497-501.

- Bengt O. (1996). Prosthodontics, Principles and Management Strategies. London: Mosby-Wolfe, pp 97.
- Binkely.T.K.&Binkley.C.J. (1987). A practical approach to full mouth rehabilitation: Journal of Prosthet Dent. 57:261.
- Bloom D and Padayachy N. (2006). Increasing occlusal vertical dimension—Why, when and how. British Dental Journal 200, 251 - 256.
- Bordoni, B., & Varacallo, M. (2020). Anatomy, head and neck, sternocleidomastoid muscle. StatPearls Publishing.
- Brandt KD, Radin EL, Dieppe PA. (2006). Yet more evidence that osteoarthritis is not a cartilage disease, Ann Rheum Dis 65:1261-1264.
- Bravetti P, Membre H, El Haddioui A, Gérard H, Fyard JP, Mahler P, Gaudy JF. (2004). Histological study of the human temporo-mandibular joint and its surrounding muscles. Surg Radiol Anat. Oct;26(5):371-8.
- Bryndahl, F. (2008). Temporomandibular joint disk displacement and subsequent adverse mandibular growth: a radiographic, histologic and biomolecular experimental study (Doctoral dissertation, Oral diagnostisk radiologi).

(C)

- Carrara SV, Conti PCR, Barbosa JS. (2010). End of the first consensus on temporomandibular disorders and orofacial pain. Dental Press Journal of Orthodontics. 2010;15(3):114–20.
- Carlier, J. F. (2012). Usefulness of occlusal splints. Journal of Dentofacial Anomalies and Orthodontics, 15(2).
- Chen C, Palla S, Erni S, Sieber M, Gallo LM. (2007). Nonfunctional tooth contact in healthy controls and patients with myoge-nous facial pain. J Orofac Pain. 21:185-93.
- Christensen, J. (1970). Effect of occlusion-raising procedures on the chewing system. Dent. Pract., 20 : 233-238.

- Clark GT: Interocclusal appliance therapy. In Mohl ND, Zarb GA, Carlson GE. (1988). Interocclusal appliance therapy. A Textbook of Occlusion, Chicago, Quintessence, pp 271-284.
- Cuccia AM, Caradonna C, Caradonna D. (2011). Manual therapy of the mandibular accessory ligaments for the management of temporomandibular joint disorders. J Am Osteopath Assoc. Feb;111(2):102-12.

(D)

- Darpan Bhargava. (2021). Temporomandibular joint disorders, principles and current practice, third edition. Bhopal, Madhya Pradesh, India.
- del Palomar AP, Doblare M. (2007). An accurate simulation model of anteriorly displaced TMJ discs with and without reduction, Med Eng Phys 29:216-226.
- Dipikia, Sathe, S., Rathi, & Borle, A. (2019). Full Mouth Rehabilitation of Severely Worn Dentition by an Interdisciplinary Approach. Journal of Evolution of Medical and Dental Sciences, 8(49), 3727-3730

(F)

- Fonseca RJ, Barber HD, Powers M., St. Louis, and MO: Saunders. (2013). Oral and Maxillofacial Trauma. Francesca and Urs Christoph. Full mouth adhesive rehabilitation of a severely eroded dentition: the three-step technique. Part1. The European journal of esthetic dentistry. Volume 3, number 1.
- Francesca and Sylvian. (2016). Treatment planning of adhesive additive rehabilitations: the progressive wax-up of the three-step technique. The international journal of esthetic dentistry. Volume 11, number3.

- Fredrik Bryndahl F, Legrell PE, Eriksson L, Isberg A. (2008). Temporomandibular joint disk displacement and subsequent adverse mandibular growth. Print & Media, Umeå, Sweden.
- Forssell H, Kalso E, Koskela P. (1999). Occlusal treatments in temporomandibular disorders: a qualitative systematic review of randomized controlled trials, Pain 83:549-560.
- Forssell H, Kalso E. (2004). Application of principles of evidence-based medicine to occlusal treatment for temporomandibular disorders: are there lessons to be learned, J Orofac Pain 18:9-22.
- Fushima K, Gallo LM, Krebs M. (2003). Analysis of the TMJ intraarticular space variation: a non-invasive insight during mastication, Med Eng Phys 25:181-190.
- Fushima K, Gallo LM, Krebs M (2003). Analysis of the TMJ intraarticular space variation: a non-invasive insight during mastication, Med Eng Phys 25:181-190.

(G)

- Gameiro GH, Da Silva Andrade A, Nouer DE, Ferraz de Arruda Veiga MC. (2006). How may stressful experiences contri-bute to the development of temporomandibular disorders. Clin Oral Invest. 10:261-8.
- Gittelson G (2005). Occlusion, bruxism, and dental im-plants: Diagnosis and treatment for success. DentImplantol. Update 16: 17-24.
- Glaros AG. (2008). Temporomandibular disorders and facial pain: a psychophysiological perspective. Appl Psychophysiol. Biofeedback. 33:161-71.
- Golding MB, Golding SR. (2010). Articular cartilage and subchondral bone in the pathogenesis of osteoarthritis, Ann N Y Acad Sci 1192:230-237.

- Golding MB, Otero M. (2011). Inflammation in osteoarthritis, Cur Opin Rheumatol 23:471-478.
- Gouw S, de Wijer A, Creugers NH, Kalaykova SI (2017). Bruxism: Is there an indication for muscle-stretching exer-cises Int J. Prosthodont 30: 123-132.
- Greene GW, Banquy X, Lee DW. (2011). Adaptive mechanically controlled lubrication mechanism found in the articular joints, Proc Natl Acad Sci U S A 108: 5255-5259.

(H)

- Hagag G, Yoshida K, Miura H. (2000). Occlusion, Prosthodontic treatment and temporomandibular Disorders. J Med Dent Sci. 47: 160-166.
- Hansson T, Öberg T. (1977). Arthrosis and deviation in form in the temporomandibular joint. A macroscopic study on a human autopsy material, Acta Odontol Scand 35:167-174.
- Haeuchi, Y., Matsumoto, K., Ichikawa, H., & Maeda, S. (1999). Immunohistochemical demonstration of neuropeptides in the articular disk of the human temporomandibular joint. Cells Tissues Organs, 164(4), 205-211.
- Haeuchi, Y., Matsumoto, K., Ichikawa, H., & Maeda, S. (1999). Immunohistochemical demonstration of neuropeptides in the articular disk of the human temporomandibular joint. Cells Tissues Organs, 164(4), 205-211.
- Heartwell, C. M. and Rahn, A. O. (1986). Syllabus of complete denture. 4th ed. Philadelphia: lea & Febiger. PP : 228-230.
- Huynh, N., Lavigne, G., Okura, K., Yao, D. and Adachi, K., 2011. Sleep bruxism.

(I)

- Iwasaki LR, Crosby MJ, Marx DB, et al, 2010: Human temporomandibular joint eminence shape and load minimization, J Dent Res 89:722-727.
- Iwasaki LR, Petsche PE and McCall WD(2003). Neuromuscular objectives of the human masticatory apparatus during static biting, Arch Oral Biol 48:767-777.

(J)

- Jonsson, G., Eckerdal, O., & Isberg, A. (1999). Thickness of the articular soft tissue of the temporal component in temporomandibular joints with and without disk displacement. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 87(1), 20-26.

(K)

- Kalaykova, S. I., Lobbezoo, F., & Naeije, M. (2011). Risk factors for anterior disc displacement with reduction and intermittent locking in adolescents. Journal of orofacial pain, 25(2), 153.
- Katase-Akiyama, S., Kato, T., Yamashita, S., Masuda, Y., & Morimoto, T. (2009). Specific increase in non-functional masseter bursts in subjects aware of tooth-clenching during wakefulness. Journal of Oral Rehabilitation, 36(2), 93-101.
- Klasser, G. D., & Greene, C. S. (2009). Oral appliances in the management of temporomandibular disorders. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 107(2), 212-223.
- Kuroda, S., Tanimoto, K., Izawa, T., Fujihara, S., Koolstra, J. H., & Tanaka, E. (2009). Biomechanical and biochemical characteristics of the mandibular condylar cartilage. Osteoarthritis and Cartilage, 17(11), 1408-1415.

(L)

- Laurel 1 L, Lundgren D. Chewing ability in patients restored with cross-arch fixed partial dentures. J Prosthet Dent. 1985; 54:720-725.
- Leonardi, R., Almeida, L. E., Trevilatto, P. C., & Loreto, C. (2010). Occurrence and regional distribution of TRAIL and DR5 on temporomandibular joint discs: comparison of disc derangement with and without reduction. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 109(2), 244-251.
- Lindauer, S. J.; Gay, T. and Rendell, J. 1991. Electromyograph-ic-force characteristics in the assessment of oral function. J. Dent. Res., 70 1417-1422.
- Lobbezoo, F., Ahlberg, J., Glaros, A. G., Kato, T., Koyano, K., Lavigne, G. J., ... & Winocur, E. (2013). Bruxism defined and graded: an international consensus. Journal of oral rehabilitation, 40(1), 2-4.
- Lobbezoo, F., Van Der Zaag, J., Van Selms, M. K. A., Hamburger, H. L., & Naeije, M. (2008). Principles for the management of bruxism. Journal of oral rehabilitation, 35(7), 509-523.
- Loreto, C., Leonardi, R., Almeida, L. E., Rusu, M., Sicurezza, E., & Palazzo, G. (2011). Tumor necrosis factor-related apoptosis-inducing ligand expression correlates to temporomandibular joint disk degeneration. Journal of Craniofacial Surgery, 22(2), 504-508.
- Lu, L., Liu, Y. D., Liao, L. F., Zhang, H. Y., Jiao, K., Zhang, M., ... & Wang, M. Q. (2014). Reducing dietary loading decreases mouse temporomandibular joint degradation induced by anterior crossbite prosthesis. Osteoarthritis and cartilage, 22(2), 302-312.

(M)

- Magne P, Belser UC. (2004). Novel porcelain laminate preparation approach driven by a diagnos-tic mock-up. J Esthet Restor Dent ;16:7-16.
- Mandeep, K., Jaidev, D., Harpeet, S., Amit, B., & Mannat, D. (2016). An Innovative Hemisection Approach Prevail Conservation Over Extraction: Two Case Reports. Baba Farid University Dental Journal, 6(1), 45-49.
- Manfredini D, Piccotti F, Ferronato G, Guarda-Nardini L. Age peaks of different RDC/TMD diagnoses in a patient population. J Dent. 2010;38:392–99.
- Manfredini, D., & Lobbezoo, F. (2010). Relationship between bruxism and temporomandibular disorders: a systematic review of literature from 1998 to 2008. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 109(6), e26-e50.
- Manns, A.; Miralles, R. and Palazzi, C., 1979. EMG, bite force, and elongation of the masseter muscle under isometric vol-untary contractions and variations of vertical dimension. J. Prosthet. Dent., 42 : 674-682.
- Margret J. Fehrenbach and Susan W. Herring., 2012. Illustrated anatomy of the head and neck.
- McNeill, C., 1997. Management of temporomandibular disorders: Concepts and controversies.
- Morani, V., Previgliano, V., Schierano, G. M., & Ramieri, G. (1994). Innervation of the human temporomandibular joint capsule and disc as revealed by immunohistochemistry for neurospecific markers. Journal of Orofacial Pain, 8(1).
- Muraoka, K., Morishita, M., Kibune, R., Yokota, M., & Awano, S. (2021). The Relationship between Periodontal Disease and Pathological Tooth Migration. J Dent Oral Biol. 6 (1), 1178.

(N)

- Naeije , M., Slater, J. J. R. H. & Lobbezoo, F., (2002). Mandibular movement characteristics of an anterior disc displacement with reduction. Journal of orofacial pain, 16(2), 135-142.
- Naeije, M. (2002). Local kinematic and anthropometric factors related to the maximum mouth opening in healthy individuals. Journal of oral rehabilitation, 29(6), 534-539.
- Nagasawa T, Tsuru H. A comparative evaluation of masticatory ef-ficiency of fixed and removable restorations replacing mandibular first molars. J Prosthet Dent. 1973; 30:263-273.
- Natiella, J. R., Burch, L., Fries, K. M., Upton, L. G., & Edsberg, L. E. (2009). Analysis of the collagen I and fibronectin of temporomandibular joint synovial fluid and discs. Journal of oral and maxillofacial surgery, 67(1), 105-113.
- Nelson SJ, Ash M. 2010. Wheeler’s Dental Anatomy. 9th ed. St. Louis, MO: Saunders.
- Nickel, J. C., and K. R. McLachlan (1994). "In vitro measurement of the frictional properties of the temporomandibular joint disc." Archives of oral biology 39.4: 323-331.

(O)

- Okeson JP. (1987). The effects of hard and soft occlusal splints on nocturnal bruxism. The Journal of the American Dental Association.;114(6):788–91.
- Ommerborn, M., Giraki, M., Schneider, C., Schäfer, R., Singh, P., Franz, M., & Raab, W. H. (2010). Correlation between stress, stress-coping and current sleep bruxism. Head & face medicine, 6(1), 1-8.

(P)

- Parviz and Janfaza (2011). Surgical anatomy of the head and neck. Harvard University Press.
- Pereira KNF, Andrade LLS, Costa MLG, Portal TF. Signs and symptoms of patients with temporomandibular dysfunction. Revista CEFAC. 2005;7:221–28.

(R)

- Richard W. Brand, Kimberly Erdman and Donald E. Isselhard., 2019. Anatomy of orofacial structures.

(S)

- Sandro Palla and Iven Klineberg (2015). Functional occlusion in restorative dentistry and prosthodontics. Edinberg, Elsevier.
- Scapino, R. P., Mills, D. K., Daniel, J. C., & Herzog, S. (1994). An animal model for studying mechanisms in human temporomandibular joint disc derangement. Journal of Oral and Maxillofacial Surgery, 52(12), 1279-1292.
- Schiffman, E., Ohrbach, R., Truelove, E., Look, J., Anderson, G., Goulet, J. P., ... & Svensson, P. (2014). Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. Journal of oral & facial pain and headache, 28(1), 6.
- Schmolke and Cordula (1994). "The relationship between the temporomandibular joint capsule, articular disc and jaw muscles." Journal of anatomy 184.Pt2: 335.

- Schubert MM, Guttu RL, Hunter LH, Hall R, Thomas R (1984) Changes in shoulder and leg strength in athletes wearing mandibular orthopedic repositioning appliances. J Am Dent Assoc 108: 334-337.
- Shen, G., and M. Ali Darendeliler (2005). "The adaptive remodeling of condylar cartilage—a transition from chondrogenesis to osteogenesis." Journal of dental research 84.8 : 691-699.
- Shet RGK, Rao S, Patel R, Suvvati P, Sadar LR, Yadav RD. Prevalence of temporomandibular joint dysfunction and its signs among the partially edentulous patients in a village of North Gujarat. J Contemp Dent Pract. 2013;14:1151–55.
- Shetty R. Prevalence of Signs of Temporomandibular Joint Dysfunction in Asymptomatic Edentulous Subjects: A Cross-Sectional Study. J Indian Prosthodont Soc. 2010;10:96–101.
- Sokolove, J., & Lepus, C. M. (2013). Role of inflammation in the pathogenesis of osteoarthritis: latest findings and interpretations. Therapeutic advances in musculoskeletal disease, 5(2), 77-94.
- Srivastava, R., Jyoti, B., & Devi, P. (2013). Oral splint for temporomandibular joint disorders with revolutionary fluid system. Dental research journal, 10(3), 307.
- Supra and infrahyoid muscles. Samuel Kennion. 2021.

(T)

- Tanaka, E., & Van Eijden, T. (2003). Biomechanical behavior of the temporomandibular joint disc. Critical Reviews in Oral Biology & Medicine, 14(2), 138-150.
- Tanaka, Y., Hayashi, K., Kumai, T., Sugimoto, K., & Takakura, Y. (2008). Correlation of compensatory alignment of the subtalar joint to the

progression of primary osteoarthritis of the ankle. Foot & ankle international, 29(4), 400-406.

- Türp, J. C., Komine, F., & Hugger, A. (2004). Efficacy of stabilization splints for the management of patients with masticatory muscle pain: a qualitative systematic review. Clinical oral investigations, 8(4), 179-195.

(U)

- Uddman, R., Grunditz, T., Kato, J., & Sundler, F. (1998). Distribution and origin of nerve fibers in the rat temporomandibular joint capsule. Anatomy and embryology, 197(4), 273-282.

(V)

- Van der Bilt A, Mojet J, Tekamp FA, Abbink JH. Comparing masticatory performance and mixing ability. J Oral Rehabil. 2010 Feb; 37(2):79-84.

(W)

- Wayler AH, Chauncey HH. Impact of complete dentures and impaired natural dentition on masticatory performance and food choice in healthy aging men. J Prosthet Dent. 1983; 49:427-433.

(Y)

- Yoshino, K., Kawagishi, S., & Amano, N. (1998). Morphological characteristics of primary sensory and post-synaptic sympathetic neurones supplying the temporomandibular joint in the cat. Archives of oral biology, 43(9), 679-686.

(Z)

- Zarb, G. A., & Carlsson, G. E. (1999). Temporomandibular disorders: osteoarthritis. Journal of orofacial pain, 13(4).