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Michigan splint and treatment of temporomandibular joint

Michiganska udlaga i liječenje temporomandibularnog zgloba

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Abstract. Splints, in a broader sense, include various groups of removable intraoral appliances which are used in biomechanical treatment approach and they help establish the neuromuscular functional balance between different parts of the stomatognathic system. The aim of the paper was to review the literature related to temporomandibular disorder (TMD) treatment with special attention given to clinical importance and the fabrication of the Michigan splint. A clinical case with a 9-year follow-up is presented within the framework of Michigan splint practical use and an evaluation of TMD treatment success until now. Generally, in TMD treatment, the principle of palliative medicine is preferred, which means treatment, control and alleviating of temporomandibular pain. The principle of non-invasive and reversible methods of treatment is preferred. The splint achieves a behavioral effect of self-awareness (cognition) about the position, function and parafunction of the mandible as well as a placebo effect.

Key words: magnetic resonance imaging, temporomandibular joint, treatment

Sažetak. Udlage u širem smislu predstavljaju velik broj skupina mobilnih intraoralnih naprava pomoću kojih se provodi biomehanička terapija te uspostavlja neuromuskularna funkcijska harmonija dijelova stomatognatog sustava. Svrha rada je pregled literature vezan uz liječenje temporomandibularnog poremećaja s naglaskom na klinički značaj i način izradbe michiganske udlage. U sklopu praktične primjene michiganske udlage i dosadašnje znanstvene evaluacije uspjeha liječenja TMP-a opisan je klinički slučaj s 9-godišnjim praćenjem. Općenito, principi palijativne medicine preporučuju se u liječenju TMP-a, što podrazumijeva liječenje i kontrolu temporomandibularnog bola. Prednost se daje neinvazivnim i reverzibilnim metodama liječenja. Udlaga postiže bihevioralni učinak samosvjesnosti (kognicije) o položaju, funkciji i parafunkciji mandibule, te se postiže učinak placeba.

Ključne riječi: liječenje, magnetska rezonancija, temoromandibularni zglob

INTRODUCTION

Temporomandibular disorders (TMDs) have a musculoskeletal origin and are part of orofacial pain problematic. As a form of somatic pain in the stomatognathic system, TMDs imply a disorder in the masticatory muscles and/or the temporomandibular joint (TMJ) with accompanying disturbances (limited mouth opening, noise and/or ear pain) as well as pathologic noise (clicking, crepitations) in the joint[1-3].

The aim of the paper was to review the literature related to treatment of TMJ with special attention paid to the clinical significance and fabrication of the Michigan splint. A clinical case with a 9-year follow-up is presented within the framework of Michigan splint practical use and an evaluation of TMD treatment success.

TMD DIAGNOSTICS

Diagnostics and differential diagnostics of TMDs are based on a standardized clinical examination. The Research Diagnostic Criteria (RDC)/TMD diagnostic system has become standard in scientific studies, wherein the clinical term TMDs has been divided into separate diagnoses[4,5]. Thus, there is a distinction between a muscular disorder and TMJ disorder: osteoarthritis and anterior disc displacement. However, the generally accepted terminology does not explain all clinical aspects of temporomandibular pain as the most important clinical sign and symptom of the illness[6].

Apart from the use of nonspecific clinical procedures (palpation, auscultation, measuring of active and passive mandibular mobility), the importance of orthopedic tests is also growing (manual functional analysis by Bumann and Groot Landeweer). This implies a modern, biomedical approach to the illness but also an individual approach to the patient and treatment procedures[7-10].

Direct occlusal analysis is carried out in everyday practice and it provides data on static contacts between teeth in supportive areas as well as on dynamic occlusal relations between the teeth – a type of laterotrusal guidance, hyperbalance and interference contacts. The significance of various static and dynamic occlusal variables has not been explained in the context of etiopathogenesis and treatment of TMDs. Although such an approach to TMDs has a strict dental focus, many patients (up to 45 %) have no indications for any kind of dental treatment[11,12]. On the other hand, the prevalence of temporomandibular pain is relatively low (around 5 %) in general population and it is disproportionate with the serious public health issue of untreated teeth and thereby, with non-replaced teeth[13-15].

The principle of occlusal therapy is the irreversibility and non-invasiveness in achieving orthopedic stability of TMJ.

MANAGEMENT OF TMDs

Etiopathogenesis of TMDs, as well as of other painful conditions of the musculoskeletal system (such as the public health issue of back pain), has not been completely explained and the treatment methods used are primarily those minimally invasive or completely noninvasive[16,17]. Concepts of etiopathogenesis only included dental causes (neuralgia as a part of Costen's syndrome) but there was also a multifactorial concept and a biopsychosocial concept (apart from the somatic, RDC/TMD includes psychiatric testing of patients). For this reason, TMDs are defined by a concept of nonspecific etiology, similarly to other musculoskeletal disorders in the body. The concept of nonspecific etiology gains importance when it has to be applied on individual patients. In such a case, the personalized approach to dental medicine/medicine plays an important role and the idiopathic etiology is often mentioned at this stage of direct contact with the patient[18,19].

Unknown etiology of TMDs and particularly of TMJs does not lessen the importance of radiological diagnostics. Apart from the panoramic radiograph as a basic document of identification for each dental patient, there are also noninvasive but rather expensive radiological methods such as magnetic resonance imaging (MRI). Although it is possible to show osteoarthritis of TMJ on images of classical and computerized tomography,

MRI has been accepted as the gold standard in diagnostics of soft intraarticular structures[20,21]. Since disc displacement is a common finding, mostly in younger population of TMD patients, MRI was accepted as the gold standard but there is still no agreement on the gold standard in TMDs treatment[22,23]. The psychological factor can be evident, even in non-characteristic geriatric population of TMD patients, and it can contribute to the general clinical picture as a recurring etiological factor[24].

Priority is given to noninvasive and reversible treatment methods where the occlusal splint plays a key role in dental, that is, initial occlusal therapy[25]. The occlusal splint is the most common and efficient treatment procedure of arthrogenic and/or myogenic forms of TMDs and bruxism. The occlusal stability is established by specific morphology of the splint which is placed on the teeth alignment of one jaw thus serving as an orthopedic means of TMJ stabilization[26].

The occlusal splint is used as a temporary means of obtaining therapeutic occlusion and as a preparatory stage for definite prosthetic treatment[27]. In treatment with occlusal splints, their biomechanical concepts of activity, characteristics of position and retention have changed and complemented each other. The morphology of the occlusal splint plane has been tested as well as its influence on mandibular position and movements and the position and relationship between the intraarticular structures of TMJ. Depending on the indications of use and treatment effects of the occlusal splint, hyperactivity is reduced, that is, the masticatory muscles are relaxed, the condyle is therapeutically positioned, which means that it is placed into the centric relation position with the behavioral effects increasing awareness about the position, function and parafunction of the mandible thus achieving placebo effect[28,29].

MICHIGAN SPLINT – CHARACTERISTICS AND FABRICATION

Relaxation splints are used in treatment of bruxism as well as in management of arthrogenic and myogenic temporomandibular pain. The Michigan splint by Ramfjord and Ash is an occlusal bite plane stabilization splint with cusped rise and freedom in centric in a space of 0.5-1.0 mm on the splint plane (Figure 1)[30]. During occlusal movements, the concept of canine guidance is realized by planes of the splint in the canines region, whereas the interference, hyperbalance and balance contacts between other teeth and splint plane are avoided[31].

Indications for Michigan splint are as follows: TMDs of arthrogenic and/or myogenic origin, management of nocturnal bruxism and uncontrolled parafunction during the day, maintaining of centric relations as a precondition to extensive prosthodontic restoration in patients with painful and stiff masticatory muscles or limited mandibular movements, and as a means of differential diagnostics of TMDs with respect to other ailments with similar symptoms (orofacial and craniocervical pain, tension headache, secondary tinnitus, etc.)[32,33].

In Michigan splint, centric relation serves as a therapeutic position which stabilizes the mandible in occlusal relations, wherein the habitual mandibular position is often identical to the centric position in the TMJ. Apart from excluding occlusal interferences, the relaxation of masticatory muscles is achieved by increasing the occlusal

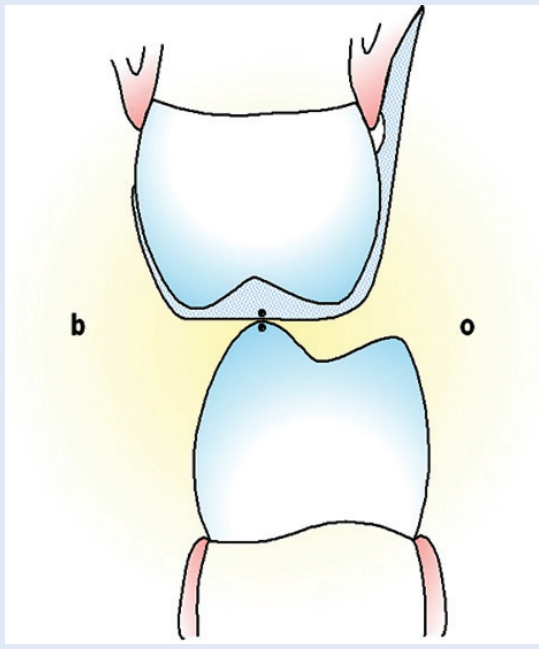

Figure 1 Antagonists are supported by working cusps of the posterior teeth on the flat occlusal plane of the splint (b, buccal; o, oral)

vertical dimension by the amount of thickness of the occlusal part of the splint. Michigan splint is most often indicated for the maxilla, but esthetic and phonetic reasons can also indicate its placement on the mandibular teeth.

Splint fabrication is of utmost importance because it has to be made individually and the dental technician has to be trained in Michigan splint fabrication. Although the methodology of fabrication is limited, apart from the method of directly applying the acrylic composite onto the definitive cast placed into the articulator, the advantage is given to the indirect method, which means that the splint is waxed-up first[11,31].

The impression of both jaws includes teeth alignment and surrounding tissues: the palate, marginal gingiva and edentulous spaces in the jaw in cases of partial tooth loss. The limits of the splint are drawn on the cast of the maxilla: vestibularly across the incisal edges of the anterior teeth (2 mm) as well as on the distal teeth in order to achieve splint retention, across the equator of the buccal planes. The palatal border follows the dental arch with the distance of 18-20 mm. Neuromuscular position of condylar centric relation is achieved by an anterior jig which is obtained by dripping aluminum wax onto the registration wax in the upper central incisors region. A definitive mandibular position in the contact position of centric relation is obtained by aluminum wax in the canine and first molars region (Figure 2)[11,34].

After mounting the cast of the maxilla into the articulator (it is recommended to use a semi-adjustable articulator with a corresponding facial arch), the incisal articulator pin is placed in the ”+2 mm” position (registration wax thickness) prior to mounting of the mandibular cast. This is followed by checking of the space (about 1-2 mm between the cusps of posterior teeth) intended for the splint in order to enable subsequent occlusal adjustment and to compensate for splint wear.

Prior to modeling of the splint, the custom model bed should be prepared: blocking out the undercuts, interdental regions and deep fissures by using modeling wax or dental plaster. This helps to avoid difficulties in applying the splint, which can be caused by unwanted changes in acrylic dimensions during polymerization. The use of vacuum-adapted resin sheet wherein the outline of the splint is then cut off the cast along the vestibular and palatal edge is optional. The vacuum-adapted acrylic sheet is waxed-up – a layer of pink wax is softened over a flame and manually molded and immediately adjusted in closing movement made in the articulator so that the incisal pin can contact the guide table in the vertical dimension. The excess wax is removed and the occlusal plane is modeled. This is followed by waxing of slightly concave planes for canine guidance in hard ˝inlay-wax˝. Finally, occlusal contacts are preliminary checked by powder.

Figure 2 Centric relation record obtained from impressions of alu-wax in contact position of centric relation

Figure 3 Vestibular edge (made by putty impression material) of the splint wax up (blue – planes for canine guidance)

The most complicated stage of laboratory fabrication is replacing the wax by acrylic, which begins by surrounding the vestibular splint edge with putty impression material. A space for excess acrylic putty is situated dorsally (Figure 3). The wax cast is replicated by dental stone fixator which will precisely copy the splint surface. By removing the hardened stone negative from the cast, the entire wax is also removed. The cast should then be isolated by a hard, clear resin sheet as well as the stone mould. The self-curing transparent acrylic is used (such as Futura Jet®, Schütz Dental). The stone mould is slowly closed in order to squeeze out the excess acrylic mass (Figure 4). The cast with splint is then placed into a pressure chamber (6 bar and temperature 40°C/15min).

The Michigan splint increases occlusal vertical dimension which has to provide comfort to the patient.

Figure 4 Eliminating of excess acrylic is checked by joining the moulage cast in lateral openings (arrows)

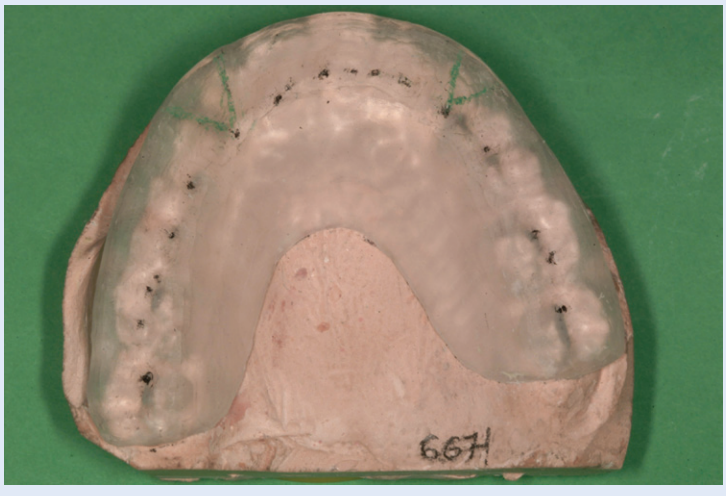

Figure 5 Even centric contacts between working cusps and incisal edges on the splint plane

The polymerized splint is not removed from the casting mould; it is mounted into the articulator for preliminary occlusal adjustment to obtain occlusal contacts in centric relations (Figure 5). After this, the canine guided movements are checked (Figure 6). The splint is then removed from the cast and the final polishing is carried out. Occlusion is also additionally adjusted when the splint is tried in by the patient.

A CLINICAL REPORT

Clicking and pain in the right TMJ appeared 6 months before the 19-year-old female patient visited our clinic, and at the time of her first visit she complained about continuous pain in the joint without clicking. Apart from the preauricular region, she also felt pain in the right ear. She rated the pain with 5.6 on the visual-analogue scale (0 – no pain, 10 – the strongest pain). She had difficulties chewing and limited mouth opening (48 mm). Laterotrusal movements were canine guided, 12 mm to the right and 7 mm to the left with pain in the right TMJ. The occlusal status was Angle class I, vertical overlap was 3 mm, horizontal was 1.5 mm whereas the incongruity of the medial line amounted to 3 mm. She did not undergo any orthodontic treatment or tooth loss, there were no wear facets and she denied any bruxist experiences. The clinical examination determined pain and limited mouth opening on active movement and under dynamic compression. The right TMJ was also painful under passive compression (bilaminar zone). An isometric examination of the muscles confirmed pain in the right masseter and temporal muscle. The definitive diagnosis was confirmed by MRI, including disc displacement without reduction (Figure 7). She was treated by Michigan splint, which she wore regularly for three months at night.

Follow-up was carried out by subsequent MRI recording after 3 months with the splint placed in the mouth. Clinical check-ups were carried out

after 6 and 12 months as well as after 5 and 9 years. A follow-up MRI was also performed then. All the procedures were carried out with the patient's written consent within the scientific study which was approved by the Ethics Committee of the School of Dental Medicine, University of Zagreb.

MRI showed DD without reduction and an osteophyte on the condyle as well as mild sclerosation of the tuberculum of right TMJ. The condyle was in the centric position which is shown on Figure 8 whereas it had a therapeutic position posteriorly within the glenoid fossa on the image with the splint applied in closed mouth position (Figure 8). The disc was displaced anteriorly in open mouth position. Regardless of the MRI finding, on check-ups, the patient had 50-51 mm painless mouth opening without clicking in the right TMJ. A long-term follow-up by MRI showed condyle in the centric position without any pronounced osteoarthritic changes. However, the disc had a less displaced position and there was reduction in open mouth position because beneficial remodeling changes correspond to the state of TMJ disorder improvement (Figure 9).

DISCUSSION

The prevalence of pain varies with age (mild pain was more frequent in younger age), with the peak occurring between 41 and 55 years of age. Another issue in the TMD epidemiology is dependence on the age and gender of the patient. Manfredini et al.[22] differentiated two age peaks (two peaks of greatest incidence) in TMD patients (30-35 and 50-55 years) with the female: male ration 5:1, which partly coincides with previous knowledge that the greatest prevalence is in women of reproductive age (that is between 18-45)[11, 35]. Mobilio et al.[13] found clicking as the most common TMD symptom (33 %), whereas pain was present in 5.1 % of subjects from the general population. Clicking can be a benign symptom of disc displacement in patients with dental anomalies in childhood[36].

The issue of occlusion in dental medicine has reached a dogmatic level, which in case of TMD patients should not apply, particularly the use of irreversible treatment methods as well as plan-

Figure 6 Canine guidance in left laterotrusal movement with the splint

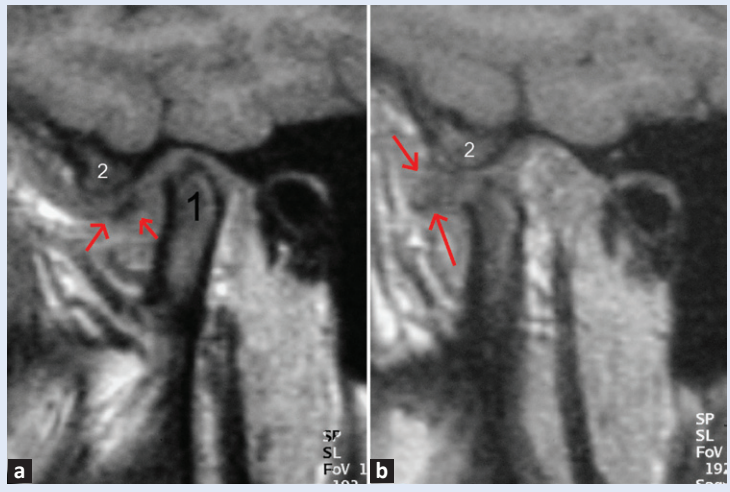

Figure 7 MRI of the right TMJ

A) in the closed mouth; B) open mouth position
Disc displacement without reduction (arrows; 1, condyle; 2 tuberculum)

Figure 8 MRI of the right TMJ with the splint applied in closed mouth position. Note: condyle was situated in a therapeutic position posteriorly within the glenoid fossa

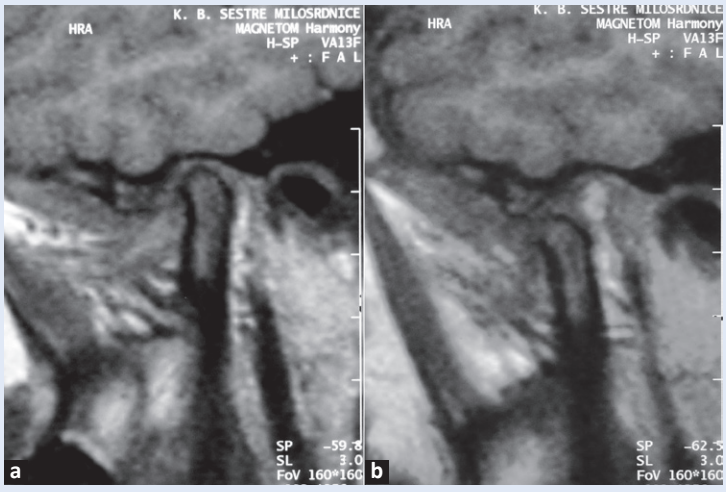

Figure 9 A long-term follow-up by MRI showed condyle in the centric position with reducing disc displacement in the right TMJ

A) closed mouth position; B) open mouth position

ning of possible preventive procedures[37]. Current opinion[19] is that TMDs are idiopathic in origin and the correlation with certain etiologic factors cannot be entirely confirmed[38]. Although MRI is the gold standard in TMJ diagnostics, there is still no gold standard in diagnostics of temporomandibular pain[39].

The importance of a correct clinical procedure used to determine centric relation is shown in the case of a patient with myalgia whose splint positioned the mandible in a non-physiological bite with shift on the left side[28]. Ferrario et al.[40] noticed that the Michigan splint achieved equilibrium in the action of temporal and masseter pairs of muscles and that it also reduced electrical activity of the muscles.

An alternative to the traditional splints are those that not require the contribution of a dental laboratory, with the so-called ˝Nociceptive Trigeminal Inhibition˝ (NTI) being the best known in the treatment of TMDs and bruxism[41]. However, it has numerous adverse effects, mostly related to changes in occlusion, as well as less efficiency compared to the Michigan splint[42]. NTI covered the upper incisors only, just like many relaxation splints from the past: the original group of relaxation splints was based on muscular relaxation achieved by elevation of occlusal vertical dimension and by removal of posterior occlusal interferences by covering only the anterior teeth (Hawley retainer, plate by Sved, anterior jig etc.).

Unlike the above mentioned relaxation splints, the Michigan splint (occlusal bite plane stabilization splint with cuspid rise and freedom in centric) by Ramfjord and Ash is a splint covering all the teeth in the jaw, enabling antagonistic contacts on the flat planes according to occlusal concepts of freedom in centric position[30,43]. The newly developed Relax splint (Unident), introduced into practice by Nilner et al.[44], has proven to be as effective in treatment of myofascial pain as the Michigan splint. On the other hand, the placebo effect of the splint on treatment of TMDs was proven in control groups of patients who wore non-occluding hard palatal oral appliance. Better efficiency of the Michigan splint and of the resilient splint was not proven in treatment of TMDs[45,46].

Within TMDs treatment modalities, physical therapy has shown efficiency in its unique methods as well as in those indicated for other musculoskeletal disorders. Namely, the basic principle of improving the function while removing pain is seen in mobilization exercises wherein the patient is directly involved. The basic exercises include performing physiological and accessory movements, such as kinesiotherapy by Schulte[47]. Physical therapy is an equivalent of the Michigan splint treatment [48]. Nonsteroidal anti-inflammatory drugs are a complementary treatment in acute pain, and apart from peroral use, they can also be applied topically[49,50].

Anterior disc displacement is perceived as a development malpositioning disc form which over time develops from a reducing to a non-reducing disc form. Also, degenerative bone changes had a significant relationship with non-reducing disc displacement[51]. On the other hand, a two and a half year follow-up of untreated painful disc displacement without reduction showed that 42.5 % were asymptomatic[52]. Apart from removing clinical symptoms, the influence of the Michigan splint was also observed in MRI studies, wherein not only the clinical success of the treatment but also the ability to recapture the previously anterior displaced disc was evident in 40 % of patients, which proved to be a greater success than the use of anterior repositioning splint[53]. On the other hand, apart from clinical treatment suc-

cess, MRI analysis did not confirm improvement in non-reducing displaced disc[54]. Hasegawa et al. reported that application of a splint resulted in anterio-inferior condylar movement, and TMJ pain was associated with decreased disc movement in response to splint in the mouth[55]. Biomechanics and load in the TMJ were never fully explained, in dynamic visualization of TMJ, Gallo[56] found disc deformation during condylar-disc complex motion, which should be taken into consideration when studying the biomechanical effects of the splint on the intraarticular structures of the joint. In conclusion, depending on the indications of use and achieving of Michigan splint therapeutic effects; there are several ways it participates in the management of TMDs. The occlusal splint has a behavioral effect which increases cognition on mandibular position and function of the stomatognathic system.

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