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Evaluation of this Temporomandibular Joint Space When Using Different Occlusal Splints by Cone Beam Computerized Tomography: A Case Report

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Eduardo Januzzi[1], Luciano Ambrosio Ferreira[1,2]*, Juliana da Silva Duarte[1], Carla Rodrigues Ribondi[1], Cira Valéria Almeida Corrêa[1], Mariana Guimarães Jorge de Alvarenga[1], Rafael Tardin Rosa Ferraz Gonçalves[1], André Mariz de Almeida[3] and Paulo João Bela Teiga de Durão Maurício[3]

[1]*Ciodonto: Rua Padre Marinho, 98 Santa Efigênia - Belo Horizonte - MG, Brasil*
[2]*Hospital Maternidade Therezinha de Jesus, Professor, Faculdade deCiências Médicas e da Saúde de Juiz de Fora- Suprema: Alameda Salvaterra, 200 - Salvaterra, Juiz de Fora - MG, Brasil*
[3]*Instituto Superior de Ciências da Saúde Egas Moniz: University Campus, Quinta da Granja, 2829 - 511, Monte de Caparica, Almada, Portugal*

***Corresponding Author:** Luciano Ambrosio Ferreira, Luiz Andrade Silveira, 207, Centenario - Juiz de Fora, MG, Brazil, Zip-code: 36045-280, Email: l3a6f9@yahoo.com.br

Abstract

Introduction: An occlusal splint is a removable, reversible, non-invasive device made of acrylic, used to promote a harmonious occlusal contact. It is part of an arsenal of therapeutic modalities used in the treatment of Temporomandibular Joint (TMJ) Disorders. However, its mechanisms of action remain controversial. Several hypotheses have been proposed to explain its efficiency, such as: repositioning of the condyle or disk; reduction of the masticatory electromyographic activity; change of harmful oral habits; increase of the intra-articular space reducing the overload on the TMJ.

Case presentation: This case report aims to demonstrate the changes in TMJ spaces, assessed by Cone Beam Computed Tomography (CBTC) scans, in a patient with indication to use occlusal splints. She was submitted to occlusal splints of 1 and 3 mm which were used during CBTC acquisition. The measures of the joint spaces with and without splints were compared by image software that shows an alteration of the upper, anterior, posterior, medial and lateral joint spaces. The 3 mm plate promoted an initial translation of condyle.

Conclusion: The thicknesses of 3 and 1 mm promoted different joint space variations. The use of different thicknesses enables the individualization of the treatment for different pathologies affecting the TMJ.

Keywords: Temporomandibular disorders, Intra-articular space, Occlusal splints, Cone beam computed tomography scans

Introduction

Temporomandibular Disorders (TMD) are referred to a group of musculoskeletal conditions involving the temporomandibular joint, masticatory muscles and / or associated structures, which may be accompanied by pain, limited mouth opening, joint sounds and *osteoarthrosis*/*osteoarthritis* [1-4].

Conservative non-surgical treatments are usually the first choice for the treatment of these disorders [3,4]. These methods include physiotherapy, pharmacotherapy, behavioural therapy and occlusal reversible adjustments, being the use of occlusal splints the most frequent one [4,5].

The occlusal splint is a reversible non-invasive removable device, usually made of hard acrylic, which fits on the occlusal surfaces to provide a harmonious occlusal contact with the antagonist teeth [5-8]. The success of the treatment, however, depends on the selection, confection and adjustment of the splint and on the patient's cooperation in using the device [5-8].

In the literature, a variety of types of occlusal splints have been described, with different indications and functions. The two most used ones are the stabilizing (myorelaxant or Michigan) and the protrusive (repositioning) [9-11]. Stabilizing occlusal splints have been frequently used as an effective treatment for sleep bruxism, to protect the teeth from damage caused by strong contractions of the jaw muscles or, if present, to reduce orofacial pain [12]. On the other hand, recent studies emphasize the importance of a well-established diagnosis of sleep bruxism through validated questionnaires and a polysomnographic study, which is considered the gold standard for the diagnosis of this condition [12].

Occlusal splints have also been used in the treatment of temporomandibular arthralgia in patients with disc displacements [13]. It is a strategy to reduce pain caused by excessive pressure in the intra - articular structures. This helps to restore the blood tissue circulation, protects against fibrocartilage overload of the joint surfaces of the head of the mandible and/or the mandibular fossa, and promotes the homeostasis of the synovial liquid, through the maintenance of the articular spaces [1,14,15].

Despite the widespread use of oral stabilizing splints for the treatment of Temporomandibular Dysfunction (TMD) and bruxism, their mechanisms of action remain controversial. Several hypotheses have been proposed to explain their real therapeutic value, including repositioning of the mandible head and/or articular disc, reduction of the electromyographic activity of the masticatory muscles, modification of the patient's noxious habits, changes in occlusion and reduction of intra-articular pressure. However, their mechanism of action is not yet fully clear [16,17].

One of the relevant indications for prescribing a stabilizing splint to articular TMD treatment is that it changes the joint space in order to reduce intra-articular pressure, to preserve the lubrication system and to control the pain, as a biomechanical strategy [18].

Decreased intra-articular space frequently leads to compression of the retrodiscal tissues and alteration of the positioning of the articular disc, which can cause pain and inflammation [18,19]. The literature states that the Cone Beam Computed Tomography (CBCT) is a reliable diagnostic tool (gold standard) for morphological evaluation and interrelation of bone tissue of the TMJ, including the measurement of intra-articular spaces [20].

CBCT is an imaging diagnostic method that uses ionizing radiation to obtain a set of high precision images processed by a computerized emission system and it has been increasingly used in the imaging evaluation of TMD [21]. This technique has the advantages of eliminating overlays, having excellent resolution, due to the great contrast of the image, and allowing the observation of mineralized structures in the sagittal, coronal and axial planes, allowing for the manipulation of images in different depths with three-dimensional view. CBCT also presents a lower cost and the patient is less exposed to radiation, when compared to a conventional tomography [20].

Based on the foregoing, the present study aims to demonstrate the results of modifications of the TMJ joint spaces when evaluated by CBCT, in a patient submitted to the use of stabilizing splints of different thicknesses (1 and 3 mm).

This study is carried out in accordance with ethical standards and Helsinki Declaration of 1975, as revised in 1983. This study was submitted to and approved by Research Ethics Committee under number CAAE 708.678. An informed consent was obtained from the patient.

Case Presentation

In order to evaluate the changes in the intra-articular space with stabilizing occlusal splints of 1 mm and 3 mm thickness, measured in the region of the first molar with more proximity to contact on the mandibular closing arch, the patient, ILL (female, 25 years old), was selected due to the diagnostic of dental clenching (awake bruxism) and arthralgia, having a clinical indication for occlusal splint therapy.

The teeth impression were made with alginate (Hydrogum®, Zhermack, Badia Polesine, Italy), and two bite registrations were made with Silagum-DMG addition silicone (Silagum®, DMG, Hamburg, Germany), one with 1 mm and another with 3 mm thickness measured in the leaf gauge in the first molar region. The models were made in type IV special stone casting material (Durone®, Dentsply Industry and trade Ltda, Petropolis, Brazil), mounted in a semi-adjustable articulator (Bio Art 4000S®, Bio Art Equipamentos Odontológicos Ltda, São Carlos, Brasil) after the use of a face bow, and sent to the prosthetic technician for making the stabilizing splints with different thicknesses – (Figure 1a to c).

Digital images of the patient's upper and lower arch were acquired with a scanner Perfactory 4 Standard Series (Envision TEC®, Gladbeck, Germany) from the cast models and used to generate virtual models of dental arches. The data sets were then processed in the software (CAD) where the design of the occlusal splint was determined. They were milled in acrylic (CAM) (Resin E-shell 600, EnvisionTEC®, Gladbeck, Germany), and finished manually using MaxIcut® mills (Maxicut®, Edenta AG, Switzerland) and One Gloss finishing tips (Shofu®, Kyoto, Japan) (Figure 2a to c).

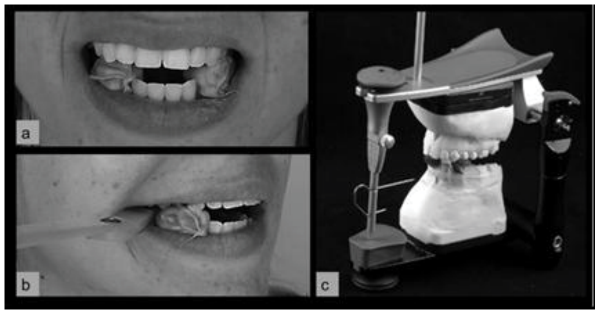

Figure 1: a: bite registrations with addition silicone
b: thickness measured in the leaf gauge in the first molar region
c: models mounted in a semi-adjustable

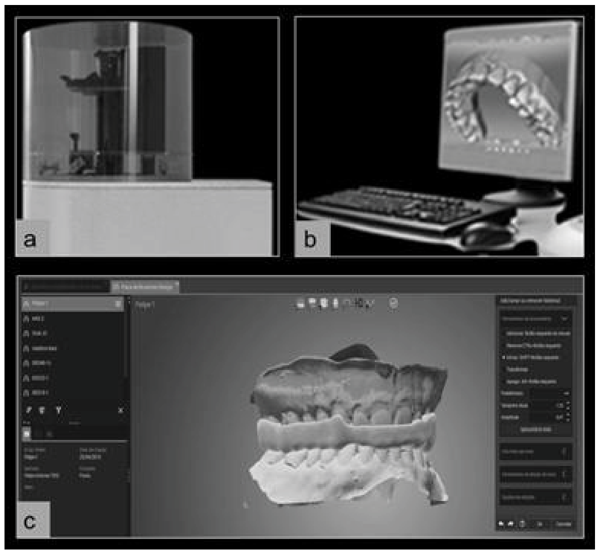

Figure 2: a: Digital images of the upper and lower arch acquired with a scanner
b: The data sets processed in the software
c: Virtual splint determined

During fittings and adjustments in the mouth, the fit, the quality of retention and the occlusal adjustment where verified, in both static (mandibular closure arch) and dynamic positions (protrusion and laterotrusion). The adjustment was made with the aid of carbon paper (Accu Film®, Parkell Inc., and Farmingdale New York, USA) and Tungsten drill (DFS Maxicut®, Edenta AG, and Switzerland). The aim was to obtain bilateral symmetrical occlusal contact points on all teeth in the position of the masticatory muscles closure arch (closest to maximum intercuspation). In terms of the dynamic dental contacts they were based on anterior guides by the incisors and laterotrusive guides by the canines. Verification and removal of posterior contacts during the protrusive movements with an incisor guide; canine laterotrusive guide on the working side with no contacts on the non-working side, respecting the principles of mutually protected occlusion [19].

After the adjustment of the stabilizing splints of 1 and 3 mm (Figure 3a to c) respectively (Figure 3), the patient was sent to the radiological center (Radiscan, Belo Horizonte - MG, Brazil). Four CBCT were acquired: rest position without splint; in MHI (Maximum Habitual Intercuspation) without splint; occlusion with the 1 mm splint; and occlusion with the 3 mm splint.

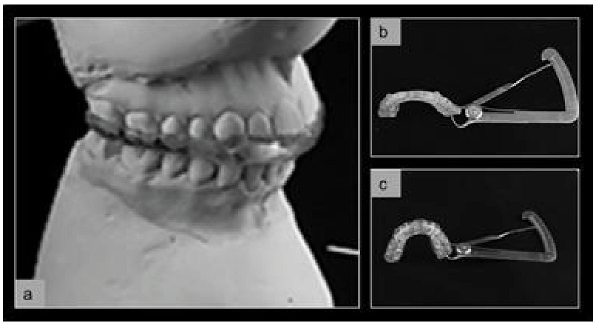

Figure 3: a: adjustment of the stabilizing splints in a semi-adjustable articulator
b: 1mm occlusal splint
c: 3 mm occlusal splint

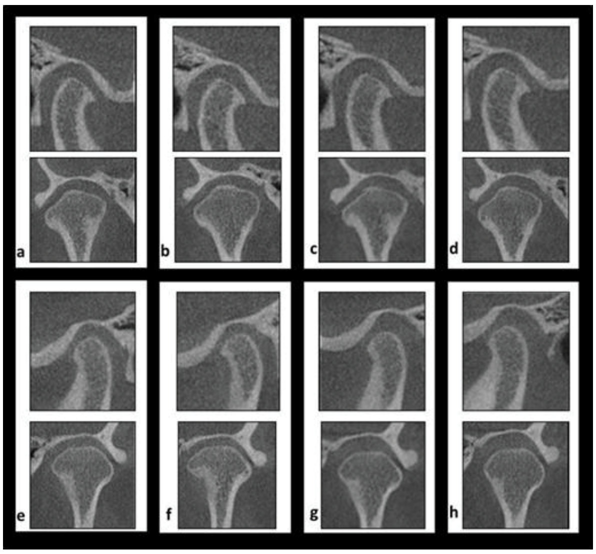

Figure 4: TMJ CBTC images: Left TMJ in sagital and coronal cuts (a- rest position; b- MHI whithout splint; c- occlusion in 1mm splint; d- occlusion with 3 mm splint). Right TMJ in sagital and coronal cuts (e- rest position; f- MHI whithout splint; g- occlusion in 1mm splint; h- occlusion with 3 mm splint).

All images were acquired on the same Tomograph (I Cat®, Kavo Imaging Science, Hatfield, PA, USA). The images were performed in the coronal and sagittal planes (Figure 4).

The criteria for interpretation of the images were based on a study by Ahmad and collaborators (2009) where a single professional, dental surgeon, specialist in Radiology and Odontological Imaginology, experienced in TMJ imaging, evaluated the images. Sagittal and coronal tomographic planes were observed with 1 mm intervals, in 300 dpi resolution images, in TIF format, visualized in the cephalometry software (Radiocef Studio 2®, Radiomemory Ltda, Belo Horizonte, Brazil). The capture ratio was 100%, resulting in a 1: 1 calibrated image, referenced to the millimeter measurement of 10 units of the tomographic scale.

The chosen region was the central portion of the condyle for the sagittal and frontal tomographic sections, because it is anatomically larger in the anteroposterior and middle lateral dimensions, representing a more faithful morphology of the mandible head.

To obtain the measures of the joint spaces we used the tools available on the software. For the sagittal cut the geometric centre of the mandible head was determined by circle tool. From its centre, lines were drawn perpendicularly to each other delimiting the horizontal and vertical planes. The anterior and posterior bisector of the superior right angles determined the anterior and posterior spaces, projected on the hypodense image corresponding to the articular space in the tomography. The vertical line determined the superior joint space.

The measures of the articular spaces in the central coronal cut were obtained by placing an imaginary ellipse in the centre of the mandible head. From the lower part of this, 4 lines were drawn: a horizontal line, connecting the extremities of the poles, which determined the horizontal limit of the articular surface; another vertical and perpendicular aligned horizontally, passing through the apex of the head of the mandible, which was used as reference for the measurement of the upper joint space; another two located 45 degrees to the right and left, which delimited the distal and medial space of the joint space.

The measurements of all spaces were delimited by the cortical limits and guided by the referenced guides of the tracings (Figure 5).

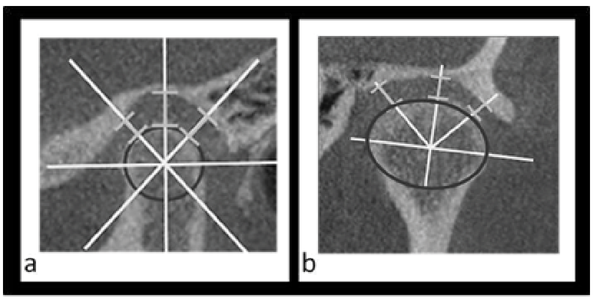

Figure 5: Measurement model in TMJ CBTC: sagittal (a) and coronal (b) cuts.

The same tracings, with the same anatomical references, were performed and compared to 4 mandibular positions: rest, MHI, 1 mm splint and 3 mm splint.

Analysing the measurements, we observed that with no splint, the articular spaces are larger at rest position and smaller in MHI, as expected, in both planes: coronal and sagittal (hence the negative sign of MHI-Rest) (Figure 4 and Tables 1-4).

In the coronal view, the medial intra-articular space is the largest bilaterally, in the natural positions (without splint), 3.78 mm on the right and 3.24 mm on the left (Table 1). When the splints were used, both CT scans showed that all joint spaces in the coronal plane were altered in relation to those obtained without the splints (all values are positive). The tomography image with the 1 mm splint showed an alteration on the right side in the distal joint space of 0.41 mm; Superior in 0.98 mm when compared to the measurements in MHI and not significantly different of the medial space (0.05 mm); On the left side: the distal spaces presented differences of 0.52 mm; superior in 2.41 mm and medially in 1.78 mm when compared to tomography measurements in MHI (Tables 1 and 2). The tomography of the 3 mm splint, on the right side showed alterations in the upper spaces of 1.32 mm and medially of 2.79 mm (Table 1) when compared to the measurements in MHI; in the left side the superior spaces presented differences of 2.79 mm and medially of 3.16 mm (Table 2) when compared to the measurements of MHI. On both sides, there was no significant change in the measurements of the distal joint space (Tables 1 and 2) compared to measurements in MHI.

In the sagittal view, CT scans showed changes mainly in the upper and posterior spaces and little change in relation to the anterior space (Tables 3 and 4) when compared to tomography measurements without the splint. The tomography with the 1 mm splint showed differences, when compared to the tomography measurements in MHI, 0.11 mm in the anterior articular space, 0.56 mm in the superior and 1.08 mm in the posterior of the right side. On the left side the upper spaces differences are of 1.85 mm, and 2.02 mm of the posterior, also compared with tomography in MHI. The difference of the anterior space on the left side is non-significant (0.06 mm) (Tables 3 and 4). The 3 mm splint in comparison with the tomography measurements in MHI promoted a difference of the upper spaces of 1.88 mm and of 4.47 mm in the posterior on the right side (Table 3) and a change of the superior spaces of 2.33 mm and 4.07 mm in the posterior on the left side (Table 4). On both sides the change was not significant in the anterior articular space (0.06 mm right and 0 in the left) compared to the measurements in MHI (Tables 3 and 4).

In the sagittal view, the 3 mm splint also seemed to promote the beginning of the translation movement of the mandible head, since its superior portion approached the posterior side of the articular tuber, causing a slight alteration of the anterior space, when compared both 1 mm and 3 mm splint.

The choice of 1 mm splint occlusal was made once the patient did not present disc displaced or severe osteoarthritis signs. The 1mm splint occlusal was indicated to relieving joint compression pain and nocturnal parafunctional habits control, without promote the motion of translation by condyle.

After 1, 3 and 6 months of reassessment, the patient was asymptomatic. The guidelines for self-control of parafunctional diurnal habits were reinforced, besides the implementation of acts of sleep hygiene and stress control.

	Rest	MHI	1mm splint	3 mm splint	Difference		
					MHI - Rest	1mm splint - MHI	3 mm splint - MHI
Distal articular space	2,67	2,52	2,93	2,62	-0,15	0,41	0,1
Superior articular space	2,52	2,25	3,23	3,57	-0,27	0,98	1,32
Medial articular space	3,78	3,06	3,11	5,85	-0,72	0,05	2,79

Table 1: Measurement of joint spaces visualized in the coronal section of the Right TMJ (mm).

	Rest	MHI	1mm splint	3 mm splint	Difference		
					MHI - Rest	1mm splint - MHI	3 mm splint - MHI
Distal articular space	1,94	1,49	2,01	1,69	-0,45	0,52	0,2
Superior articular space	2,74	1,98	4,39	4,77	-0,76	2,41	2,79
Medial articular space	3,24	2,14	3.92	5,3	-1,1	1,78	3,16

Table 2: Measurement of joint spaces visualized in the coronal section of the Left TMJ (mm).

	Rest	MHI	1mm splint	3 mm splint	Difference		
					MHI – Rest	1mm - MHI	3 mm - MHI
Distal articular space	2,09	1,67	1,78	1,73	-0,42	0,11	0,06
Superior articular space	3,18	2,67	3,23	4,55	-0,51	0,56	1,88
Medial articular space	1,98	1,97	3,05	6,44	-0,01	1,08	4,47

Table 3: Measurement of joint spaces visualized in the sagittal section of the Right TMJ (mm).

	Rest	MHI	1mm splint	3 mm splint	Difference		
					MHI - Rest	1mm splint - MHI	3 mm splint - MHI
Distal articular space	1,92	1,65	1,71	1,65	-0,27	0,06	0
Superior articular space	3,4	2,54	4,39	4,87	-0,86	1,85	2,33
Medial articular space	2,79	2,24	4,26	6,31	-0,55	2,02	4,07

Table 4: Measurement of joint spaces visualized in the sagittal section of the Left TMJ (mm).

Discussion

The stabilizer occlusal splint is made from the molding of the upper and lower arch, with bite registrations and mounting of the models in the semi-adjustable articulator. The production of the splints can be manual or digital [13]. In this study, it was decided to make the plates using the digital method, according to the studies of Deden and Turp (2016) [22] that showed that this method produces more accurate splints, as it uses a material of higher quality and can be duplicated.

Radiographic and tomographic examinations have specific indications for the diagnosis of TMD in the evaluation of hard tissues. Radiographic examinations have lower costs, lower doses of radiation, less sensitivity and are used for less complex diagnoses. CT scans are more sensitive and specific for TMJ morphological examination, bone fractures, and joint degeneration. Cone Bean-type tomography is considered the gold standard for the evaluation of maxillofacial hard tissue [20] and it was the reason why it was used in this investigation.

In this study, a small difference was observed between the measurements made on the right and left articular spaces. The same was observed in studies made by Christiansen, et al. (1986) [23] and Hatcher, Blom and Baker, (1986) [24], who demonstrated that there are differences and concordances regarding the use of TMJ joint space measurement for diagnosis. According to these authors, the reasons are the technological advancement of radiographic techniques, and factors such as bone structure, soft tissues and also by the lack of uniformity of joint spaces. These findings contradict the study carried out by Matos, et al. (2005) [25] that report an apparent symmetry in the maintenance of these spaces, regardless mandibular changes and deviations.

Casares, Thomas and Carmona (2014) [13] and Zhang, Zhao and Han (2008) [18] analysed the intra-articular pressure in the upper compartment of the TMJ and concluded that the stabilizing splints can reduce the intra-articular pressure in the ATM, improving its functional state. The results of the present study demonstrated that both splints, 1 mm and 3 mm, even in different proportions, promote the opening of the joint space, which seems to be relevant for the reduction of the intra-articular pressure, and may contribute to the improvement of the symptoms of pathologies related to joint overload and TMJ tissue compression.

Reichardt, et al. (2013) [19] in their study observed that the mandible head- mandibular fossa relation seemed to create a "discharge" condition for the temporomandibular joint. This study demonstrated that the use of a 3 mm thick occlusal splint led to the redistribution of the distance from the mandible- mandibular fossa to the TMJ, resulting in lower anterior movement and rotation of the mandible head in the opening direction, the same was confirmed in studies of Hasegawa, et al. (2011) [26] and Ettlin, Mang and Colombo, (2008) [14].

It is expected that the increase in joint space of 1 and 3 millimeter splints may differentiate its therapeutic indication. If the therapeutic aim is only to relieve joint compression, the 1mm splint would be the most indicated because it does not promote the translation of the mandible head. On the other hand, if the intention is to interfere with the position of the disc, releasing it and/or throwing it more anteriorly, as in the cases of disc displacement without reduction, the 3mm splint seems to be more indicated by performing a beginning of translation of the head of the mandible. However, caution is necessary when indicating the 3 mm splint because, according to Hasegawa, et al. (2011) [26], it may cause an adverse effect due to the increase in the vertical dimension, promoting a greater difficulty of adaptation by the patient and the risks of posterior open bite.

This is a preliminary study with some limitations; this type of study can be considered as a pilot-case and should be used to instigate further studies, with greater sample number, and higher strength of evidence. If this methodology is used to a larger population, other variables may interfere with the results, such as the facial growth pattern (class I, II or III), the presence of morphological alterations of the bone tissues and the different phases and positions of the displacements of the articular discs, and need to be controlled. In addition, the symptomatic and biomechanical of the TMJ of the patients submitted to different thicknesses of stabilizing splints should be observed as a secondary outcome.

Conclusion

CBCT was an effective imaging technique to check the joint changes occurred as a result of splints occlusal modification.

The present case report demonstrated that the use of the 1 mm and 3 splints promoted alteration of the intra-articular space and can be recommended when it is desired to increase the joint spaces for pain relief and decreasing the intra-articular pressure in the TMJ.

The initial translation motion of condyle was observed by the CBCT examination when the use of 3 mm splint, which may be useful when intra-articular disc disorder, is diagnosed.

The splint occlusal with different thicknesses enables the individualization of the treatment for different pathologies affecting the TMJ.

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