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Clinical Paper
TMJ Disorders

Is there a correlation between arthroscopic findings and the clinical signs and symptoms of patients with internal derangement of the temporomandibular joint? A prospective study

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Abstract. The aim of this study was to evaluate the correlation between clinical signs and symptoms of patients with internal derangement of the temporomandibular joint (TMJ) and arthroscopic findings. The study included a sample of 67 patients who underwent TMJ arthroscopy. The variables evaluated were the arthroscopic findings of synovitis, chondromalacia, adhesion, and roofing. The Spearman correlation index was used to correlate these findings with the clinical signs and symptoms of internal derangement of the TMJ, namely maximum mouth opening, pain (visual analogue scale, VAS), and the Wilkes classification. The mean age of the population was 36.16 years, and 85% were female. There was a correlation between pain and synovitis ($P = 0.0029$, $r = 0.3508$), between mouth opening limitation and the amount of adhesion ($P = 0.0004$, $r = -0.4084$), and between Wilkes classification and the presence of chondromalacia and disc displacement ($P = 0.001$, $r = 0.374$ and $P = 0.0045$, $r = -0.3357$, respectively). No correlation was found between age and the presence of chondromalacia ($P = 0.3444$, $r = 0.1147$). Patients who had worse pain symptoms had more advanced stages of synovitis, and the increased presence of adhesions was associated with limitations in mouth opening. Furthermore, those with more advanced Wilkes stages had greater disc displacement and more severe stages of chondromalacia.

Key words: arthroscopy; temporomandibular joint; synovitis; temporomandibular dysfunction; arthralgia; trismus.

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Temporomandibular disorder (TMD) is a collective term for a group of conditions involving the temporomandibular joint (TMJ), the muscles of mastication, and the associated structures. These disorders are relatively common, affecting about 30% of the population, and can be classified as muscular, articular, or a combination of both[1].

Internal derangement of the TMJ is by definition an abnormal relationship between the condyle–disc–fossa, which may be accompanied by pain, limited mouth opening, and click[2]. The evaluation of disc position and integrity has traditionally formed the basis of the diagnosis of internal derangement of the TMJ. However, it is now believed that the pathogenesis of these disorders is associated with a change in the physiological activity of synovial cells and the presence of inflammatory mediators in the TMJ, and disc displacement is now considered much more a consequence than a cause of TMD[3].

Treatment options for patients with TMD range from non-surgical or reversible therapies (anti-inflammatory drugs, muscle relaxants, occlusal splints, physical therapy, laser therapy, cognitive behavioural therapy, among others) to surgical or irreversible therapies, which may be classified as minimally invasive procedures (such as arthroscopy and arthrocentesis) or open procedures[2]. Before the advent of arthroscopic surgery of the TMJ, many patients with conditions that were refractory to conservative treatment directly underwent open surgery[4].

Arthroscopy is a diagnostic option demonstrated in the literature to have high sensitivity and specificity[5], that allows the evaluation of intra-articular pathologies such as synovitis, capsulitis, chondromalacia, and degeneration, as well as the determination of the location and type of adhesions in the upper compartment of the TMJ[6,7]. When compared to the tests traditionally used in the diagnosis of internal disorders, it has the advantage of allowing treatment during the same surgical appointment in which the diagnosis is made and in a minimally invasive manner[8–11].

The main pathological changes found during arthroscopic procedures are adhesions, synovitis, chondromalacia, and disc displacement. The latter is assessed by the roofing, i.e. the degree of coverage of the condyle by the articular disc, which is related to the degree of disc displacement. Previous studies in the literature have shown that adhesions are more frequent in older patients with a longer duration of mouth opening restriction[12], and that the distribution of synovitis in the upper joint space is positively correlated with the level of arthralgia reported by the patient[13].

The pathogenesis of internal derangement of the TMJ remains controversial[14] and there are few studies correlating clinical signs and symptoms with the arthroscopic findings[10]. The purpose of this study was to evaluate the correlation between clinical signs/symptoms and characteristics of patients with TMD and arthroscopic findings.

Materials and methods

Study design

In order to address the purpose of the research, the researchers designed and implemented a prospective and observational study, which was submitted to and approved by the local research ethics committee.

The study population consisted of all patients who presented for the evaluation and treatment of a TMD at the General Hospital of Vila Penteado and the Department of Oral and Maxillofacial Surgery of the State University of São Paulo (UNESP) College of Dentistry of São José dos Campos between July 2014 and July 2016. The study sample included patients with a clinical and imaging diagnosis of TMD that was refractory to non-surgical treatments (non-steroidal anti-inflammatory drugs, occlusal adjustment, muscle relaxants, occlusal splints, and physiotherapy) after at least 3 months.

Patients with any comorbidity for which an arthroscopic procedure under general anaesthesia was contraindicated, those with overlying skin infections, those with bilateral dysfunction that was refractory to treatment, and those with a history of a previous surgical procedure in the TMJ (arthroscopic or open surgery) were excluded. Patients were also required to have only unilateral pain in order to prevent interference with the perception of pain symptoms and more particularly with mandibular movements (mouth opening) between the sides of the joint, since the TMJs are the only joints of the body working together joined by a single bone (jaw).

Before completion of the arthroscopic procedures, all patients underwent a magnetic resonance imaging (MRI) examination of the affected TMJ. The anteroposterior disc positioning and possible degenerative joint changes were evaluated, and these data were used to classify the sample by Wilkes stage[11]. For the purpose of this work, only the joint on which the surgical procedure was performed was considered for Wilkes classification and disc displacement.

Clinical examination

A clinical examination was performed by a single examiner (CAAL) immediately before the arthroscopic procedure. Each patient's main complaint, degree of pain (measured using a 0–10-cm visual analogue scale (VAS)), and maximum mouth opening (in millimetres) were recorded.

Magnetic resonance imaging (MRI)

Before the procedure, all patients were submitted to MRI of the side on which the arthroscopy procedure was performed. The disc positioning was classified according to the criteria of Drace and Enzmann as follows[12]: (1) disc in the normal position; (2) anterior displacement with reduction; (3) anterior displacement without reduction.

Arthroscopic procedure

The same surgeon (FRLS) performed all of the arthroscopic surgeries. A 1.9-mm 30-degree arthroscopy system (Karl Storz GmbH, Tuttlingen, Germany) was used on the upper joint space of the TMJ, under general anaesthesia. The arthroscopic procedure began with the infiltration of 2–3 ml of 2% lidocaine without vasoconstrictor in the skin and in the TMJ. A sharp-tipped trocar was then used to enter the upper joint space. Once the capsule had been punctured (the surgeon confirmed the input by the presence of returned fluid in the cannula), a blunt trocar was used in place of the sharp-tipped trocar. Next, the 1.9-mm arthroscope was inserted, and an initial diagnostic scan of the upper joint space from posterior to anterior was done. Capsular distension and intermittent washing with lactated Ringer's solution was maintained through an open irrigation system, and the arthroscopic structures of seven regions were analyzed, according to the method of González-García et al.[13]: medial synovial curtain, pterygoid shadow, posterior slope of the articular and glenoid eminence, articular disc, intermediate zone, and anterior recess.

After performing the arthroscopic lysis and lavage (arthroscopy level 1), and according to the intra-articular pathologies found in this first step, an operative arthroscopy (arthroscopy level 2) was next

performed. In cases of disc displacement, procedures of disc repositioning (arthroscopy level 3) were then performed, with the technique of McCain et al.[14]. However, for this study only the information from the first step of the procedure (arthroscopy lysis and lavage) was considered.

Data were recorded in a standardized way using pre-defined scales, described in the section below, for the following variables: roofing, synovitis, chondromalacia, and adhesions. The data were recorded by two researchers (CAAL and GT), both with prior calibration, and the data were compared after the procedure; when there were divergences in the classification, the video of the procedure was examined by both researchers and a consensus was obtained with the participation of the surgeon (FRLS). By using this methodology, the classification of the pathologies was more accurate, avoiding subjective evaluation and possible bias.

Study variables

The primary predictors of this study were the clinical signs and symptoms of internal derangement of the TMJ: (1) articular pain, measured subjectively using a 0–10-cm VAS; (2) mouth opening limitation, evaluated with the aid of a millimetre ruler, considering the inter-incisal distance (in millimetres); (3) Wilkes stage[11], ranging from 1 to 5, based on clinical signs and symptoms and findings on MRI scans.

The arthroscopic findings were analyzed by two examiners (CAAL and GT) in a double-blind controlled method and the results classified as categorical variables in a standardized way. Roofing, synovitis, chondromalacia, and adhesions were assessed as outlined below.

Roofing was classified as described by McCain et al.[7], as the coverage of the condyle by the disc when the condyle is in a mouth opening position, expressed as a score from 0% to 100%. In normal TMJs, with the articular disc in the normal position, the roofing is 100%. With the displacement of the disc, the score approaches 0%.

With regard to synovitis, normal synovial tissue is vascular, but hypervascularity is characteristic of a disease. The level of vascularity was evaluated based on the criteria established by McCain et al.[7]: 0 = normal, with whitish synovial tissue and wire capillaries; 1 = light hypervascularity, with larger capillaries; 2 = moderate hypervascularity, with the presence of petechiae; 3 = severe hypervascularity, with the presence of broad areas of petechiae/ecchymosis.

For chondromalacia, degeneration of the fibrocartilage and articular disc, when present, was classified according to the scale proposed by McCain et al.[7]: 0 = normal, completely smooth, smooth white surface with striations on the surface; 1 = surface degeneration; 2 = intermediate degeneration, with fibrocartilage with bubbles, but without bone exposure; 3 = advanced degeneration, with evident bone exposure throughout the joint.

With regard to adhesions, early inflammatory changes initiated by macrotrauma or microtrauma can lead to the loss of lubrication of the synovial fluid. The lubrication loss progresses, leading to increased surface 'friction', resulting in capsular fibrosis and relative immobility of the TMJ, which can subsequently mature and vascularize, thereby increasing restrictions on movement. Adhesions were categorized using the Kaminishi classification[15]: (1) simple fibrous band: less resistant adhesions, covered by synovial tissue; (2) fibrosynovial band: more 'mature' adhesions and more difficult to break, surrounded by fibrous tissue; (3) pseudowall: large adhesions that divide the upper space of the joint into compartments.

Statistical analysis

Exploratory data analysis techniques including the mean, median, and standard deviation were used for the evaluation of the results of this study. The comparison of roofing between the groups with anterior disc displacement with and without reduction was done using the Mann–Whitney test. The correlations between the other study variables were assessed using the Spearman correlation coefficient. All hypothesis tests developed in this study considered a significance level of 5%.

Results

The sample consisted of 67 patients, 57 female (85% of the sample) and 10 male (15% of the sample). The mean age of the patients was 36.16 years, the youngest being 20 years old and the oldest being 75 years old (Table 1).

Regarding the clinical variables, the patients had a mean mouth opening of 34.79 mm and a mean pain VAS score of 6.54. The mean Wilkes stage was 2.6 (Table 1). The arthroscopic findings showed a mean roofing of 44%, mean synovitis level of 1.74, mean chondromalacia level of 1.06, and mean adhesion level of 0.53 (Table 1).

Table 1. Characteristics of the study patients.

Variable	Mean	Median	SD
Age	36.16	34	12.40
Wilkes stage (1–5)	2.6	2	0.75
Mouth opening (mm)	34.79	35	9.57
Pain (0–10)	6.54	7	2.02
Roofing (0–100%)	44	50	30.76
Synovitis (1–4)	1.74	2	0.81
Chondromalacia (1–4)	1.06	1	0.93
Adhesions (0–3)	0.53	0	0.75

SD, standard deviation.

The MRI data showed that all discs were displaced according to the criteria of Drace and Enzmann[12]. Out of the total of 67 joints, 38 (56.7%) presented anterior displacement with reduction and 29 (43.3%) presented displacement without reduction. On comparison of roofing between the two groups (anterior displacements with and without reduction) using the Mann–Whitney test, a statistically significant difference was found ($P = 0.0069$), showing that the cases of displacement without reduction presented a lower roofing than the cases of displacement with reduction (Table 2).

Spearman's rank correlation coefficient was used to evaluate the relationship between clinical and arthroscopic findings. There was a statistically significant correlation between pain (VAS) and synovitis ($P = 0.0029$, $r = 0.3508$). The positive correlation coefficient indicates that patients in more pain had higher amounts of synovitis (Table 3 and Fig. 1).

A statistically significant negative correlation was found between mouth opening and adhesions ($P = 0.0004$, $r = -0.4084$). The negative correlation coefficient indicates that patients with smaller mouth opening presented more adhesions (Table 3 and Fig. 2).

The correlation between age and adhesions was not statistically significant ($P = 0.4578$, $r = 0.0889$). This indicates that the calculated coefficient cannot be considered statistically different from zero, i.e., it was not possible to validate the assumption that the older the patient, the greater the amount of adhesion (Table 3). Still in relation to age, there was no statistically significant correlation with chon-

Table 2. Classification of disc positioning according to the MRI, and its relationship with arthroscopic roofing.

	Sample (n)	Roofing
Anterior displacement		
With reduction	38	51.3 ± 28.2
Without reduction	29	31.7 ± 30.9
P-value		0.0069

MRI, magnetic resonance imaging.

Table 3. Correlations between the study variables: Spearman's rank correlation coefficient (r) and P-values.

Correlation between:	r	P-value
Pain (0–10) and synovitis (0–4)	0.3508	0.0029[a]
Mouth opening (mm) and adhesions (0–3)	−0.4084	0.0004[a]
Age and adhesions (0–3)	0.0889	0.4578
Chondromalacia (1–4) and age	0.1147	0.3444
Wilkes stage (I–V) and chondromalacia (1–4)	0.374	0.001[a]
Roofing (0–100%) and Wilkes stage (I–V)	−0.3357	0.0045[a]

[a] Statistically significant, $P < 0.05$.

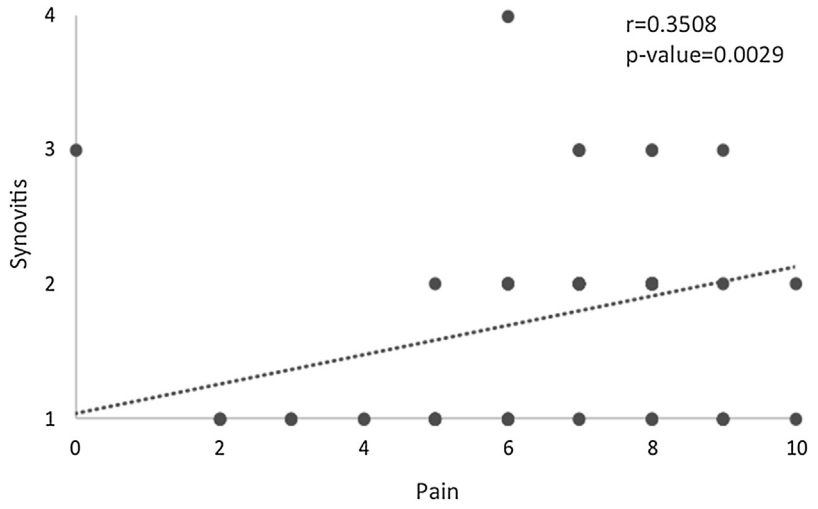

Fig. 1. Scatter plot for the correlation between pain and synovitis.

dromalacia ($P = 0.3444$, $r = 0.1147$). It is not possible to say that the calculated correlation coefficient is statistically different from zero. So it was not possible to validate the assumption that the older the patient, the greater the amount of chondromalacia (Table 3).

When the Wilkes classification was evaluated for the presence of chondromalacia, a positive correlation was found ($r = 0.374$) with statistical significance ($P = 0.001$) (Fig. 3).

Finally, there was a statistically significant correlation between roofing and the Wilkes stage ($P = 0.0045$, $r = -0.3357$). The negative coefficient of correlation indicates that the smaller the degree of roofing, the greater the Wilkes stage, validating the assumption under study (Table 3 and Fig. 4).

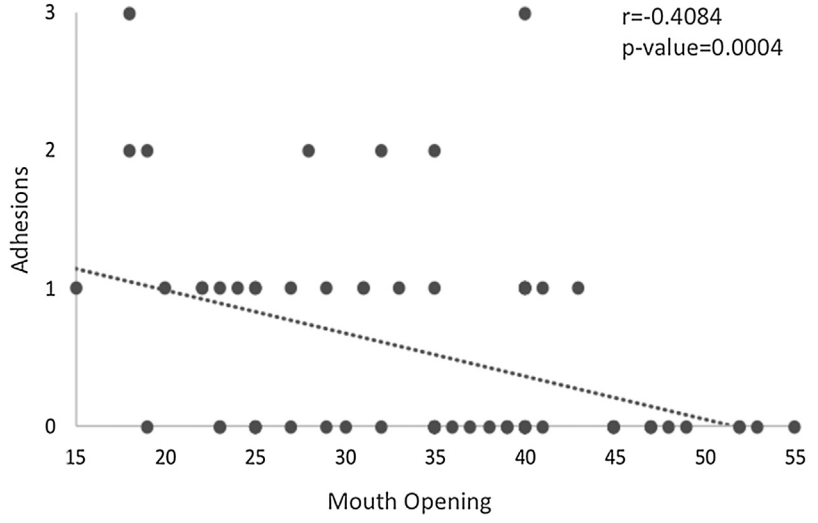

Fig. 2. Scatter plot for the correlation between mouth opening and adhesions.

Discussion

The purpose of this study was to evaluate the correlation between clinical signs and symptoms of patients with internal derangement of the TMJ and arthroscopic findings. For this purpose, the study was based on the correlation of joint pain, degree of mouth opening limitation, and the Wilkes classification with intra-articular pathologies identified during the arthroscopy procedure. The purpose was to check whether there is a correlation between pain and synovitis, adhesions and mouth opening limitation, patient age and greater restriction of mouth opening, and more advanced stages of Wilkes classification and chondromalacia.

The results of this study confirmed some of the assumptions made by the authors, such as the correlation between pain represented by the VAS and synovitis, between mouth opening limitation and greater amounts of adhesion, and between worse Wilkes stage and less roofing, in addition to the correlation between more advanced levels of chondromalacia and more advanced Wilkes stages. However, some other assumptions were not confirmed, for instance between older age and more adhesions, as well as between older age and more advanced levels of chondromalacia.

The positive correlation found in this study between pain symptomatology and higher classifications of synovitis corroborates the classic study of Murakami et al.[16], which evaluated 28 patients with internal derangement of the TMJ and also found a positive correlation between pain and synovitis, showing that inflammation of the synovial tissues causes pain for the patient. This is in contrast to the study of Holmlund and Axelsson[10], which evaluated 200 patients with internal derangement of the TMJ and found that although 153 (77%) patients showed symptoms of synovitis, there was no statistical correlation between pain and synovitis. This dichotomy can perhaps be explained by the differences in the methods used for the inclusion and exclusion of patients in these studies, as well as the time at which the procedure is indicated in the natural course of the disease. In the study of Holmlund and Axelsson[10], patients with muscle pain were not excluded, which is in contrast to the present study and the study by Murakami et al.[16]; it is possible that the presence of patients with myalgia in the sample interfered with the results of the

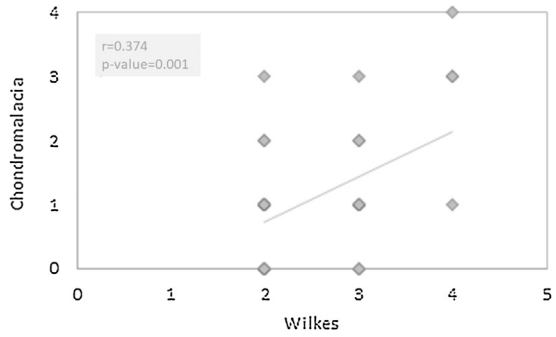

Fig. 3. Scatter plot for the correlation between Wilkes stage and chondromalacia.

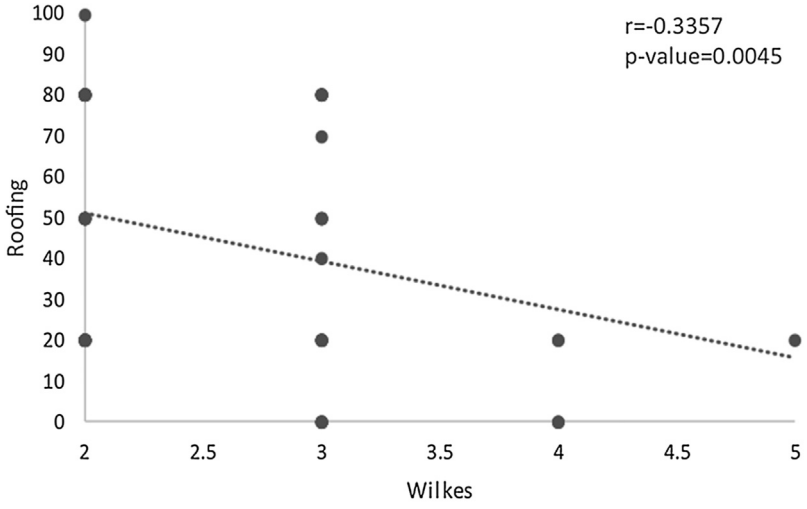

Fig. 4. Scatter plot for the correlation between roofing and Wilkes stage.

study by Holmlund and Axelsson[10]. Moreover, the classifications of synovitis used were different. Holmlund and Axelsson used their own classification[10], with synovitis ranging from 0 to 2. Murakami et al. also used their own classification[16], with synovitis ranging from 0 to 10. In the present study, the classification proposed by McCain et al.[7] was used, with levels of 0 to 3.

The inversely proportional relationship between mouth opening and adhesions found in this study is in accordance with the study of Murakami et al.[17], which evaluated 28 patients with internal derangement of the TMJ and concluded that the intra-articular adhesions are one of the factors contributing to the limitation of mouth opening in patients with internal derangement. The results are also in agreement with those of Zhang et al.[6], who evaluated 1822 TMJs and found that the incidence rate of adhesions was high and that they occurred mainly in older patients with trismus (more chronic cases). Based on these data, it is of fundamental importance to release these adhesions during the arthroscopy procedure.

Of course, it is not possible to assert that all cases of trismus are caused only by the presence of adhesions, as disc displacement is also a well-known important mechanical impairment for the normal function of the TMJ[18]. However, studies have shown evidence that the aetiology of disc displacement is related to prolonged overload of the articulation, with the formation of free radicals that cause disruption of the lubrication system[3], which increases the friction between the surface of the disc and fossa, leading to the anterior dislocation of the disc. Similar to the pathophysiology of disc displacement, Kaminishi and Davis proposed two theories for the onset of adhesions and articular degeneration[19]. The first is that alterations in the lubrication system of the joint and the presence of synovitis subsequently lead to fibrin deposition and the onset of adhesions. The second theory is based on the healing process of haematomas in the synovial membrane, which promotes the formation of scar tissue and adherences.

The most severe degrees of chondromalacia are related to higher clinical and functional impairment of the TMJ. More advanced levels of chondromalacia have been found in patients at a more advanced Wilkes stage. This is similar to what was demonstrated in the study of Smolka and Ilzuka (2005)[20], which showed the presence of articular cartilage fibrillations only in the later Wilkes stages (IV and V). Another positive correlation found in this study was between the coating of the disc in relation to the condyle (roofing) and the Wilkes stage, a relatively obvious result, since the Wilkes stage takes into account, among other things, the disc displacement diagnosed by MRI[21], which helps validate the results of this work.

Still in relation to disc positioning, when comparing roofing findings between disc displacement with and without reduction identified on MRI, a statistically significant difference was found, demonstrating that roofing is a good criterion to evaluate the degree of disc displacement and that there is a difference in this disc positioning in cases of disc displacement with and without reduction. These data are similar to those reported by McCain et al.[7], who also demonstrated that roofing is an excellent variable to study the quality and function of the articular disc during the arthroscopy procedure.

This study found no statistically significant correlation between the level of chondromalacia and the age of the patient. No other study on the direct correlation between age and the presence of chondromalacia could be identified; however Israel et al. showed that chondromalacia is related to the presence of parafunctional habits[22], which may present at any age.

The use of well-defined inclusion and exclusion criteria, in addition to the prospective study design, made it possible to select a homogeneous sample, without large disparities and with minimal factors that could negatively interfere with the results. To avoid subjective analysis and bias, the methodology used a double-blind controlled evaluation by two researchers and a well-defined classification that already exists in the literature for each variable studied.

Other signs of internal derangement, such as protrusion and laterality, were not assessed in this study, and this represents a limitation that could have adversely affected the results. However, the authors believe that the use of mouth opening measurement and the consequent evaluation of mouth opening limitation is the most important sign of functional restriction of the mandible. Furthermore, the same functional evaluation model of mandible movement, i.e. only by means of

mouth opening measurement, has been used in several previous studies, for example in the works of Murakami et al.[17] and Zhang et al.[6].

The results of this study showed that the symptom of joint pain is related to the intensity of synovitis and that the presence of adhesions is related to the limitation in mouth opening. It follows also that the greater the disc displacement, the worse the degree of articular alteration according to Wilkes classification.

Funding

None.

Competing interests

None.

Ethical approval

The local research ethics board approved the study (CAAE protocol: 44981615.7.0000.5446) in accordance with the Declaration of Helsinki 1975 and amendments thereafter.

Patient consent

Written informed consent was obtained from all patients.

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