Treatment Effects of Maxillary Flat Occlusal Splints for Painful Clicking of the Temporomandibular Joint

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Existing therapies for symptoms related to painful clicking of the temporomandibular joint (TMJ) have rarely met with complete success and predicting prognosis remains difficult. Few studies have reported the efficacy of maxillary flat occlusal splints (MFOSs) for the treatment of painful clicking of the TMJ, and few studies have evaluated the predisposing factors that influence the clinical outcomes of MFOSs. The aim of this study was to investigate the treatment efficacy of MFOSs for painful clicking of the TMJ, and to determine the factors influencing TMJ therapy with MFOSs. We conducted a retrospective study of 109 patients suffering from unilateral clicking concurrent with preauricular area pain for at least 2 months between 2004 and 2008. Seventy-five patients were treated with an MFOS, while 34 patients did not receive MFOS therapy. Clicking score, pain-free maximal mouth opening, pain score, duration of the clicking sounds, age and bruxism were recorded during treatment and involved into the reviews. The degree of joint clicking was determined by a stethoscope placed in the anterolateral area of the external auditory canal and was divided into four grades. Data were analyzed using a Mann-Whitney *U* test, Fisher's exact test, and Student's *t* test. Results showed statistically significant differences in treatment outcomes between the MFOS-treated and control groups in clicking index, maximal mouth opening, pain and complete remission rates of symptoms within 1 year. Furthermore, for patients treated with MFOS, there were statistically significant differences in the clinical outcomes between those with a high clicking index and those with a low index before treatment. Factors significantly correlated with successful outcomes of MFOS included nocturnal bruxism, patient age and duration of clicking. MFOSs can be used to treat patients with painful clicking of the TMJ and related symptoms. The severity of clicking, bruxism, age and duration of clicking are all important factors influencing treatment outcomes with MFOSs.

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Patients visiting the oral and maxillofacial surgery departments in Taiwan commonly complain of pain associated with clicking of the temporomandibular joint (TMJ). The clicking sound is often associated with psychological anxiety and patient discomfort. Some patients also suffer from adjacent muscle pain,

limited mouth opening, and difficulty speaking. In advanced cases, these symptoms may negatively impact the patient's social interactions and self confidence. One possible reason for TMJ clicking is a mechanical functional disorder in the joint area that bears the pressure [1]. Another possible source of TMJ clicking may be a structural and functional disorder in the joint cavity caused by anterior disc displacement with reduction (ADDR) [2,3]. Occlusal splints are widely used in clinical practice as a conservative treatment for internal TMJ disorders and to reduce the related symptoms [4–7]. Currently, there are various designs of occlusal splints that have different functions. However, only the stabilization splint can provide "relatively ideal" occlusion, decrease abnormal muscle activity, increase the vertical height of occlusion, and stabilize the TMJ [8]. The stabilization splint is also considered an effective reversible treatment of TMJ disorders (TMDs) [9].

Posselet et al first introduced the flat occlusal splint to treat TMDs and clicking [10]. Compared with other occlusal splints, the flat occlusal splint is relatively easy to make. Furthermore, it is easy to place and adjust clinically [11]. The flat occlusal splint has also been documented to resolve muscle pain, limited mouth opening, and internal TMDs [12,13]. Although some studies have proposed benefits of maxillary flat occlusal splints (MFOSs) for managing myofacial pain and limited mouth opening, few studies have reported the use of MFOSs for the treatment of painful clicking of the TMJ.

In recent years, studies have increasingly focused on the predisposing factors involved in painful clicking of the TMJ. However, little has been done to determine the predisposing factors influencing the clinical outcomes of MFOSs. This retrospective comparative study was conducted to investigate the therapeutic effect of MFOSs on painful clicking of the TMJ and pain-free maximal mouth opening (MMO). We also analyzed the association between predisposing factors and clinical outcomes of MFOSs in patients with painful clicking of the TMJ. This study also predicted the possible clinical outcomes in terms of the treatment of painful clicking, and the resolution of patient distress. Although clicking sounds are significant presenting symptoms of ADDR, this study focused on the clinical treatment and evaluation of the effects of MFOSs on painful clicking, and was not limited to the treatment of ADDR.

Methods

Patient collection and definitions

A retrospective study of 109 patients with unilateral clicking of the TMJ, TMJ pain on palpation, and a history of clicking sounds for at least 2 months was conducted in the Department of Oral and Maxillofacial Surgery, Chang Gung Memorial Hospital-Kaohsiung Memorial Center between 2004 and 2008. Among the 109 patients, 75 patients (Group A) underwent MFOS therapy, while 34 patients (Group B) refused MFOS therapy. The patients in Group B did not accept MFOS treatment because of individual factors such as time, economics, insomnia due to the use of the splint, the sensation of a foreign body (i.e. the splint).

All subjects met the following criteria: (1) the presenting symptoms met the diagnosis for clinical ADDR in the TMJ, as defined in "The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)" proposed by Dworkin in 1992 [14]; (2) patients presented with clicking sounds of the unilateral TMJ only and with no other sounds such as crepitation or grating; and (3) the clicking sound was eliminated during mouth opening and closing when incisors were protruded to an edge-to-edge position. To be accepted in the study, patients showing symptoms of TMJ clicking had to fulfill all three of the inclusion criteria. In addition, magnetic resonance imaging of the TMJ was required if the patients eligibility could not be determined based on these three criteria for clinical ADDR. In addition, all patients had to satisfy the following requirements: (1) no systemic disease, arthritis or history of condylar trauma; (2) no arthrosis changes in the condylar head or genial tubercle on panoramic X-ray, computed tomography or magnetic resonance imaging; (3) missing no more than two posterior teeth (excluding third molars); (4) strict patient compliance during treatment or follow-up; and (5) no treatment with any other therapy specific for TMD or medication before the current therapy.

Patients were fully informed about the treatment procedures, care, follow-up examinations, and alternative treatment options. Before starting therapy, each patient signed a consent form in accordance with the Declaration of Helsinki. The mean ± standard deviation age of patients in Group A (21 males, 54 females) who continued treatment in the outpatient department

was 35.8 ± 14.6 years (range, 15–71 years) and that of patients in Group B (11 males, 23 females) was 38.2 ± 16.11 years (range, 16–72 years).

Outcome measures

Patient age, presence or absence of nocturnal bruxism, pain free MMO, pain score during function, and duration of joint clicking were recorded on the first visit. Nocturnal bruxism was defined as awareness of tooth grinding or clenching during sleep noted by a sleep partner or a family member. On examination, signs of bruxism included tooth attrition with unexpected wearing, scalloping of the lateral border of the tongue, and ridging of the buccal cheek mucosa along the occlusal line. Severity of TMJ pain was evaluated using a visual analog scale (VAS) (0–100), written as described by Westesson et al [15]. The VAS is considered to be a reliable and effective method for evaluating TMJ pain [14]. In a standard hearing test room with a silent background (≤ 30 dB SPL), a 3M Littmann stethoscope (3M, St Paul, MN, USA) was used to detect joint clicking in the anterolateral area of the external auditory canal upon MMO and closing. According to the Wabeke detection method for joint clicking [16], the patient was trained with a metronome to perform MMO and closing once every 2 seconds. The same physician examined all patients, and examinations were performed to detect four episodes of joint clicking upon MMO and closing. In addition to recording self reported TMJ clicking, the physician listened for clicking while observing each episode of MMO and closing. In addition, the physician needed to verify that only the affected joint produced the clicking. The intensity of joint clicking was classified into four grades (0–3). Grade 0 was defined as no joint clicking detected by a stethoscope upon MMO and closing. Grade 1 was defined as faint joint clicking heard by a stethoscope upon MMO and closing. Grade 2 was defined as joint clicking that was clearly heard by a stethoscope at each instance of MMO and closing. Grade 3 was defined as joint clicking that was clearly heard by the physician 30 cm away from the patient, without the aid of a stethoscope, when the patient opened and closed his/her mouth. This classification presented a simple and convenient method to grade the clicking sound. Its progressive stages allowed for clear grading, and the patient could assess his or her own current clinical presentation.

Occlusal splint fabrication and delivery

In Group A, after a full-mouth impression, a centric relation record and face bow registration were carried out for each patient, and an MFOS was fabricated with a semi-adjustable articulator. The same dentist applied an occlusal splint according to Posselet's method to eliminate the occlusal interference that occurs during protrusive and lateral movements [10].

After adequate relief undercutting and relining of the splint to ensure stable placement, the first objective was to establish a centric relation occlusion, i.e. simultaneous and even contact between the splint and all opposing teeth in the centric relation jaw position. Occlusion was provided between the splint and one cusp tip of each opposing tooth. Repetitive adjustments of the splint were made until the full range of centric stops was achieved. The ideal anterior guidance was developed next. All interfering structures were identified by lateral and protrusive mandibular excursion, and were systematically removed.

Therapeutic interventions

Patients in Group A were asked to insert the occlusal splint every night before going to sleep for at least 3 months. The patients also underwent physical therapy, such as hot packing and massage of the affected areas, medical control for 1 week (analgesics and muscle relaxants, 4 times/day), and followed a soft diet. After treatment, the patients were asked to return to the clinic every 2 weeks for an oral examination and splint adjustment. In Group B, patients only underwent physical therapy, such as hot packing and massage of the affected areas, medical control (same drug, dose and duration as in Group A), and followed a soft diet. Patients in Group B were asked to return for an oral examination every 4 weeks.

It has been reported that the optimal duration of time to evaluate occlusal splint therapy is 90 days [17]. Therefore, we conducted our evaluation 90 days after occlusal splint treatment. After 90 days, the patient's joint clicking, pain free MMO and pain region were recorded. The average pain score during function in the last 2 weeks was also recorded. All patients were followed up for at least 1 year after receiving treatment and the complete remission rates of all symptoms (clicking, pain, opening limitation and opening deviation) were recorded for advanced analysis. Complete remission within 1 year was defined as all symptoms

being resolved after therapy, and no recurrence of TMD within 1 year. Patients were required to wear a splint for 3 months after all symptoms had subsided. Patients with habitual bruxism were asked to continue wearing the splints.

Data analysis

Student's *t* test was used to statistically analyze differences in pain, pain-free MMO, and χ^2 test was used to statistically analyze total remission rates within 1 year between Groups A and B. The Mann-Whitney *U* test was used to statistically analyze differences in the clicking index between the two groups. At 90 days, Fisher's exact test was used to statistically analyze the therapeutic effect of clicking associated with presence or absence of bruxism, a high (3) or low (≤2) clicking index before treatment, age, and clicking duration. We also used receiver operating characteristic curve analysis and c statistics to triangulate the period of clicking and patient's age to predict the best tangent for the clinical outcome. If treatment failed (i.e. clicking could be detected after treatment), we evaluated whether clicking duration and patient's age were potential factors that predicted the effectiveness of treatment.

Results

Mean age of patients in Groups A and B was 35.8 and 38.2 years, respectively. In Groups A and B, respectively, 13 and five patients were 10–20 years old, 21 and nine were 21–30 years old, 12 and five were 31–40 years old, 16 and seven were 41–50 years old, nine and three were 51–60 years old, three and four were 61–70 years old, and one patient in both groups was 71–80 years old. Before treatment, the mean duration of clicking was 15.0 months in Group A and 13.3 months in Group B. Student's *t* test showed no statistical differences between the two groups in terms of age ($p = 0.505$) or clicking duration ($p = 0.728$). Furthermore, there were no differences between the two groups in terms of bruxism ($p = 0.832$).

In Group A, TMJ pain improved significantly in 86.7% (65/75) of the patients, and TMJ clicking completely disappeared in 57.3% (43/75) of patients after 90 days of treatment. In Group B, TMJ pain improved significantly in 73.5% (25/34) of patients, and TMJ clicking completely disappeared in 14.7% (5/34) of patients after 90 days of treatment. Post treatment, the Mann-Whitney *U* test showed a statistically significant difference between Groups A and B in the clicking index ($p < 0.001$) (Table 1). Furthermore, Student's *t* test showed statistically significant differences between Groups A and B in the mean MMO ($p < 0.001$), VAS for pain ($p = 0.03$) (Table 2), and complete remission

Table 1. Statistical evaluation of differences in outcomes according to clicking index between patients treated with (Group A) or without (Group B) a maxillary flat occlusal splint

Symptom	Mean ± SD	Median (Min–Max)	*p*
Clicking sound before therapy (0–3)			
Group A	2.17 ± 0.70	2 (1–3)	0.706
Group B	2.12 ± 0.73	2 (1–3)	
Clicking sound after therapy (0–3)			
Group A	0.56 ± 0.74	2 (0–3)	< 0.001
Group B	1.88 ± 1.09	0 (0–2)	

*Mann-Whitney *U* test. SD = standard deviation.

Table 2. Statistical evaluation of the differences in maximum mouth opening, pain score, and complete remission rates of symptoms within 1 year between patients treated with or without a maxillary flat occlusal splint*

Symptom	Maxillary flat occlusal splint		*p*†
	With	Without	
Pain-free MMO (mm)			
Before therapy	31.36 ± 6.31	31.85 ± 4.35	0.638
After therapy	43.11 ± 5.70	38.47 ± 4.84	< 0.001
Pain score (0–100)			
Before therapy	59.27 ± 21.10	53.97 ± 18.94	0.213
After therapy	8.27 ± 11.13	17.50 ± 22.81	0.030
CRR of symptoms within 1 year (%)	61.3	20.6	< 0.001

*Data presented mean ± standard deviation. †Student's *t* test; MMO = maximum mouth opening; CRR = complete remission rate.

rates of symptoms within 1 year (61.3% *vs*. 20.6%; $p < 0.001$).

Ninety days after treatment, the clicking sound had disappeared in 83.7% of 49 patients from Group A whose clicking index was ≤2 before starting treatment. However, the clicking sound remained in 88.5% of the 26 patients whose clicking index was 3 before treatment. There was a statistically significant difference in clinical outcomes (clicking index 0 *vs*. ≥1) of MFOSs between patients with a clicking index of 3 versus those with an index of ≤2 before starting treatment, according to Fisher's exact test ($p < 0.001$). In Group A, we also found that there was a difference in the duration of clicking between the successfully and unsuccessfully (0 *vs*. ≥1) treated patients.

The receiver operating characteristic curve and c statistics analysis revealed that the best predictive validity was achieved if 9 months of clicking duration was used to predict the clinical outcomes of MFOSs (Figure). The success rate of treatment was only 40.4% in patients whose duration of clicking exceeded 9 months. However, if the duration of clicking was < 9 months, the treatment success rate reached 89.3% ($p < 0.001$) (Table 3). Using the same method, we found that the best tangent of age for predicting clinical outcomes was older or younger than 26 years. The success rate of MFOS treatment for painful clicking of the TMJ was also 78.3% in patients without bruxism. However, the success rate decreased to 27.6% in patients with bruxism ($p < 0.001$). In summary, factors that were significantly correlated with successful outcomes of MFOS included a clicking index of ≤2, the absence of bruxism, patient age of <26 years, and duration of clicking <9 months. Of note, the clicking index was greater in patients with a longer duration of clicking sounds before treatment. Age played a significant role in the degree of clicking index before therapy. Similarly, clicking sound was greater and duration of clicking was longer in patients with bruxism, based on correlation coefficients (data not shown). Even though the clicking sound could not be completely eliminated in some patients, the majority of the patients treated in this study experienced a significant amelioration of pain and increased MMO.

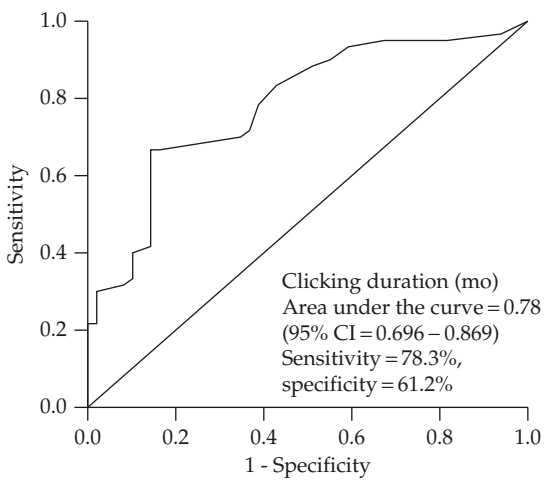

Figure. *The receiver operating characteristic curve and c statistics were used to determine the best tangent for the duration of clicking and age for clinical outcomes. Duration of clicking of >9 months and age ≥26 years had the strongest validities for predicting treatment efficacy. CI = Confidence intervals.*

Discussion

Joint clicking is a relatively common symptom of TMDs, affecting 17–38% of patients [17,18]. One of the main symptoms of ADDR is TMJ clicking [14,17]. Although the reason for internal displacement of the TMJ remains unclear, the main cause of disc displacement is suspected to be instability in the structure and function between the TMJ and occlusion. Occlusal factors

Table 3. Statistical evaluation of the differences in therapeutic outcomes associated with clicking severity, bruxism, age, and clicking duration of the temporomandibular joint in patients treated with a maxillary flat occlusal splint according to the clicking index after therapy ($n = 75$)*

	Clicking index after therapy		$p^{\dagger}$
	0	≥1	
Clicking index before therapy			
≤2	41 (83.7)	8 (16.3)	<0.001
3	3 (11.5)	23 (88.5)	
Bruxism			
No	36 (78.3)	10 (21.7)	<0.001
Yes	8 (27.6)	21 (72.4)	
Age (yr)			
<26	18 (85.7)	3 (14.3)	0.003
≥26	26 (48.1)	28 (51.9)	
Clicking duration (mo)			
<9	25 (89.3)	3 (10.7)	<0.001
≥9	19 (40.4)	28 (59.6)	

*Data presented as *n* (%); †Fisher's exact test.

may increase the activity of the masticatory muscles, which induces joint overloading, and occlusion of an overloaded TMJ may result in disc displacement [1–3]. If overloading is compensated for by disc displacement, other related symptoms might not occur. If it exceeds the compensatory balance, further changes in the joint may occur. In fact, mechanical overload of the TMJ can result in pathological degeneration of the joint [19]. If such imbalances continuously exceed the compensatory balance of structural changes, further symptoms, including pain in the TMJ area or masticatory muscles, and limited mouth opening, can occur. Furthermore, ADDR may be characterized by abnormal activity of the masticatory muscles. Mechanical limitations in the movement of the condyle head of the joint can also increase muscle activity. ADDR can progress to anterior disc displacement without reduction in the absence of treatment [17]. However, this study did not focus on the treatment of ADDR or return the disc to its normal position. In fact, we focused on the main effects of MFOSs on painful clicking.

Stabilizing splints are thought to stabilize physiologically static and dynamic occlusion, relax the masticatory muscles, and stabilize the physiological stress relationships in joint structures [20]. However, successful treatment with splints may also be influenced by psychological effects, such as an increase in cognitive consciousness of oral habits, a placebo or Hawthorne effect, and spontaneous remission of the symptoms [21]. Some studies have suggested that the clinical signs and symptoms of internal displacement of the TMJ spontaneously resolve over time without treatment. Nevertheless, the total symptom remission rate was only 28–43% with a great variation in symptomatology at the end of these studies [22,23]. Sato et al also found that noise in the TMJ remained unchanged at various follow-up times during the subsequent natural course [22].

There are many predisposing factors that influence TMDs [24]. MFOSs have been used to treat TMDs, including internal displacement of the TMJ, clicking and pain, to provide an effective and reversible treatment that could easily be produced and used for long periods [9,11]. Although an anterior repositioning occlusal splint can also be used to treat joint clicking [25], its production and adjustment are complicated and time consuming. Furthermore, patients who use this type of splint experience significant early discomfort and it is recommended that these splints be used for <6 weeks [11]. In addition, anterior repositioning occlusal splints are considered to be an irreversible treatment because they can change the position of the condyle head [26].

One of the most significant clinical presentations of ADDR is the clicking sound and TMJ clicking can be detected in 67.5–82.0% of patients with ADDR [2,5,27]. Pullinger et al suggested that the development of ADDR seems to be related to the form and position of the various articular tissues within the TMJ [27]. The development of ADDR may be related to space insufficiency within the joint that prevents the condyle and disc from being jointly accommodated in the fossa upon reentrance [28].

Currently, joint clicking can only be classified based on the frequency or velocity of the clicking sound, but its degree cannot be classified. In this study, we tried to classify the degree of clicking detected by a stethoscope. Clinically, this offers a convenient and easy method for dentists, and is very helpful in evaluating the clinical status at each visit. The influence of artificial interference is reduced when joint clicking is detected by a stethoscope outside the external auditory canal upon MMO and closing [16]. In this study, we focused on the therapeutic effects of MFOSs and evaluated the predisposing factors likely to affect the treatment of painful clicking. Therefore, we assessed the clicking sound and pain free MMO using standardized procedures, which were designed to prevent observer bias. Notably, in 61.3% of the patients, the TMJ clicking completely disappeared with the use of MFOSs within 1 year. These results demonstrate the relatively high treatment efficacy of MFOSs, which outperformed other stabilizing occlusal splints (33% and 57%) [24]. It is thought that the use of MFOSs decrease joint noises by increasing joint space, allowing smoother condylar translation beyond disc surface irregularities and positional abnormalities [29]. Therefore, disc morphology can progress with the development of a new functional balance between occlusion, muscles of mastication, disc, and condyle [29,30].

When evaluating the severity of joint clicking before treatment and the efficacy of treatment with MFOSs, we found that the clicking disappeared completely in patients with lower grade of clicking index. The severity of disc displacement may affect the position where joint clicking is detected when the mouth is opened. Joint effusion is likely to change the mechanical properties of the intracapsular tissues. Changes

in the acoustic characteristics of TMJ sounds may be associated with joint effusion. Joints with effusion showed more unstable sound patterns than joints without effusion during movement [31]. Therefore, prognosis may be affected the presence of capsulitis and the amount of effusion [32].

It has also been reported that disc deformation of the TMJ with internal displacement can be divided into upward and downward flexures. Comparing the treatment efficacies of these two types of flexure after treatment with a flat occlusal splint, the improvements in TMJ pain and masticatory muscle pain were significantly greater in patients with downward flexure of the disc than in patients with upward flexure of the disc [7]. Therefore, we propose that the degree of joint clicking before treatment and the prognosis after treatment may be correlated with the extent of deformation of the joint disc. To our knowledge, there is no clear or practical method to clinically test the magnitude or severity of TMJ clicking sounds. The classification used here is a simple and convenient method to grade clicking sounds. Its progressive stages allow for clear grading, and the patient is able to assess his or her own current clinical status.

For doctors specializing in TMDs, painful joint clicking is difficult to treat [5,14]. Because many factors influence this disorder, it is difficult to predict an individual patient's prognosis at an early stage of treatment [33]. Indeed, very few studies have evaluated the association between clinical outcomes of MFOSs for painful clicking and predisposing factors such as the duration of clicking, the presence of bruxism, and the patient's age. Therefore, we specifically analyzed these factors. We found that the clicking sounds disappeared in 83.7% of patients whose clicking index was ≤ 2 before treatment, but the clicking sounds remained in 88.5% of patients whose clicking index was 3 before treatment. We also discovered that the presence of clicking sounds for 9 months before therapy, age over 26 years, and the presence of bruxism, could influence the clinical outcomes of MFOSs (poorer prognosis). The statistical analysis showed that these factors influenced the treatment outcomes and partially explained the individual differences in treatment success for TMJ clicking in this study. However, the number of patients was limited in this study. Further studies on larger patient populations and a longer follow-up of the efficacy of MFOSs are needed to confirm these findings.

MFOSs can be used to treat patients with painful TMJ clicking. The fabrication and adjustment of this splint are relatively convenient and simple, and the splint can significantly decrease or eliminate TMJ clicking, relieve pain, and improve pain free MMO. Factors that were significantly influence the successful outcomes of treatment of painful TMJ clicking using MFOSs included a clicking index of ≤ 2, the absence of bruxism, patient age of < 26 years, and duration of clicking < 9 months.

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以上顎平坦型咬合板治療疼痛性顳顎關節彈響聲的療效

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罹患疼痛性顳顎關節彈響聲是很難根治與預測癒後的。目前只有少數研究特別評估使用上顎平坦型咬合板來治療疼痛性顳顎關節彈響聲與影響上顎平坦型咬合板療效的因素，這個研究的主要目的在於評估上顎平坦型咬合板的療效與影響治療結果的因素。回顧性研究 **109** 位罹患單側疼痛性顳顎關節彈響聲患者，**75** 位（**group A**）接受上顎平坦型咬合板治療，**34** 位（**group B**）則無。這兩組患者都予以記錄治療前後彈響聲指數、最大張口度、疼痛指數、罹患彈響聲時間、年紀與是否會夜間磨牙。彈響聲指數的偵測是以聽診器放置於外耳道的前外側區加以偵測，共分 **4** 級（**0–3**）。研究結果經統計分析發現，兩組間在彈響聲指數、最大張口度、疼痛指數與 **1** 年內症狀的根治率都有統計上的差異；而在 **group A** 患者之中治療前罹患彈響聲指數的高低，罹患彈響聲時間、年紀與是否會夜間磨牙皆會影響療效。使用上顎平坦型咬合板可以治療疼痛性顳顎關節彈響聲，治療前罹患彈響聲指數的高低，罹患彈響聲時間、年紀與夜間磨牙會影響上顎平坦型咬合板的療效。

關鍵詞：夜間磨牙，彈響聲，上顎平坦型咬合板，顳顎關節

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