Int. J. Oral Maxillofac. Surg. 2018; 47: 755–761
https://doi.org/10.1016/j.ijom.2017.10.019, available online at https://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Clinical Paper
TMJ Disorders

Comparison of two physiotherapy programmes for rehabilitation after temporomandibular joint arthroscopy

W. A. Abboud[1,2], N. Yarom[3], R. Yahalom[1], M. Joachim[1], S. Reiter[3], O. Koren[3], H. Elishoov[3]
[1]Department of Oral and Maxillofacial Surgery, Sheba Medical Center, Affiliated to Tel-Aviv University, Tel-Hashomer, Israel; [2]Institute of Movement Disorders, Department of Neurology, Sheba Medical Center, Affiliated to Sackler School of Medicine, Tel-Aviv University, Tel-Hashomer, Israel; [3]Department of Oral Pathology and Oral Medicine, School of Dentistry, Tel-Aviv University, Tel-Aviv, Israel

W.A. Abboud, N. Yarom, R. Yahalom, M. Joachim, S. Reiter, O. Koren, H. Elishoov: Comparison of two physiotherapy programmes for rehabilitation after temporomandibular joint arthroscopy. Int. J. Oral Maxillofac. Surg. 2018; 47: 755–761.

Abstract. The purpose of this study was to compare two physiotherapy programmes for rehabilitation after temporomandibular joint (TMJ) arthroscopy. The medical files of 137 consecutive patients diagnosed with closed lock and treated by arthroscopic lysis and lavage were analyzed retrospectively. Sixty-eight patients were rehabilitated with gradually increasing range of motion self-exercises (gradual programme) and 69 patients were rehabilitated with immediate full range of motion self-exercises (immediate programme). The outcome variables were maximum mouth opening (MMO) and pain (on a visual analogue scale). The postoperative measurements taken at 1 month, 6 months, and last follow-up examination available (mean of 10 months postoperative) were analyzed and compared between the two groups. The results showed significantly better MMO and pain outcomes for the immediate group than for the gradual group at the 1-month and 6-month postoperative evaluations. The results of the two groups were comparable at the last follow-up examination available. It is concluded that after arthroscopic treatment of closed lock of the TMJ, a physiotherapy programme consisting of immediate postoperative full range of motion mobilizations achieves better results (in terms of pain and mouth opening) than a physiotherapy programme consisting of gradual and controlled increases in range of motion.

Key words: temporomandibular disorder; closed lock; physiotherapy; physical therapy; arthroscopy.

Accepted for publication 23 October 2017
Available online 15 November 2017

Physiotherapy (PT) is an integral part of rehabilitation after temporomandibular joint (TMJ) surgery and is intended to help patients achieve their full potential[1–3]. Arthroscopic lysis and lavage is a widely accepted treatment for closed lock of the TMJ and is aimed at eliminating the mechanical interferences that restrict joint mobility[4–13]. While there are numerous clinical trials reported in the literature on the topic of TMJ arthroscopy, there are very few

publications reporting postoperative PT rehabilitation.

The aim of post-arthroscopic PT is to prevent secondary immobilization of the patient, which carries the risk of cicatricial tissue formation, adhesions, and contracture of the healing tissues, with further limitation of range of motion. In addition, PT aids the adaptation of the joint structures and masticatory muscles to the newly formed range of motion, promotes healing of tissues, strengthens and re-trains the muscles of mastication, and improves function[14–18].

Remarkable agreement appears to exist between proposed post-surgical PT protocols with respect to aims and procedures[1,19,20]. The majority agree that mobilization techniques, both exercises performed by the patient themselves (self-exercise) and hands-on exercises guided by a physiotherapist, constitute the primary treatment modality during rehabilitation[21–27]. Furthermore, the majority of PT protocols comprise a three-stage programme in which the first stage involves pain-free hinge-only movements (for 1–2 weeks postoperative), the second involves active and assistive exercises aimed at gradually increasing range of motion (usually performed for 1–2 months postoperative), and the third is aimed at strengthening and re-educating the muscles of mastication to further improve function[1–3,14,28,29].

The intention of these protocols is to achieve full range of motion gradually, in a controlled fashion, in a matter of weeks after surgery. The rationale behind the gradual and controlled increases in range of motion is to prevent early over-stretching of the healing tissues, which could increase the inflammatory process during the early postoperative recovery phase and compromise joint tissues[2]. In addition, it is argued that early full range of motion mobilization necessitates the unnecessary consumption of analgesics and could affect patient cooperation with the exercises and motivation to participate actively in the rehabilitation programme. Although a broad scientific basis for these post-surgical TMJ PT protocols is lacking, empirical and some scientific evidence has been gathered regarding their beneficial effects[1].

The classic three-stage gradually increasing range of motion PT protocol was implemented in the Department of Oral and Maxillofacial Surgery of Sheba Medical Center for years. This protocol has recently been changed to a rehabilitative programme that starts with full range of motion mobilizations immediately after surgery, starting in the recovery room. Instead of starting the PT exercises with rotational movements and increasing the excursions in a gradual manner until reaching full range of motion within 2–3 weeks after surgery, patients initiate full range of motion mobilizations immediately after arthroscopy. The rationale behind this shift was the finding that the joint was freely and easily movable in full range of motion at the end of the operation, and when not adequately mobilized, some rapid loss of the newly achieved range of motion occurred, probably due to the scarring inherent in the healing process[30–32].

The purpose of this study was to compare the efficacy of the two PT programmes in terms of regaining full mouth opening, decreasing pain, and returning to good function.

Materials and methods

The series consisted of 137 consecutive patients with closed lock of the TMJ treated by arthroscopic lysis and lavage in the study department over a 4-year period. The cohort was divided into two groups depending on the postoperative PT programme implemented. The first group consisted of 68 patients treated between September 2012 and November 2014, who were rehabilitated with a PT programme aimed at achieving full range of motion gradually in a matter of 2–3 weeks after surgery (gradual programme). The second group consisted of 69 patients treated between November 2014 and July 2016, who were rehabilitated with a PT programme consisting of full range of motion exercises immediately after surgery (immediate programme).

The diagnosis of closed lock, corresponding to both Wilkes stage III internal derangement[33] and the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) category 'disc displacement without reduction with limited opening'[34], was based on preoperative anamnestic, clinical, and imaging evaluation, and intraoperatively on arthroscopy findings[35]. Clinically, mouth opening was less than 35 mm and the patients complained of a somewhat abrupt development of limitation in mouth opening. Prior to the limitation patients could have been asymptomatic, have suffered from clicking, or have suffered from intermittent locking and transient pain episodes. The involved joint was symptomatic in at least three of the five following clinical examinations: assisted opening (opening stretch), palpation, contralateral loading, contralateral excursion, and protrusion. Magnetic resonance imaging (MRI) demonstrated an anteriorly displaced articular disc without reduction on opening. The disc morphology varied from near-normal to various degrees of folding and thinning; however, there were no signs of degeneration of the joint structures. MRI scans were performed with various machines, but all included at least closed- and open-mouth proton density-weighted images in the sagittal oblique plane, closed-mouth T1-weighted images in the true coronal plane, and closed mouth T2-weighted images in the axial plane. All scans were performed within less than 8 months from the arthroscopic intervention and were interpreted by a radiologist specialized in head and neck radiology.

At Sheba Medical Center, the minimum waiting time for a non-oncological elective surgical procedure under general anaesthesia is in the range of 5 months. Patients diagnosed with closed lock of the TMJ are referred for conservative treatment consisting of splint therapy, non-steroidal anti-inflammatory drugs (NSAIDs), and guided PT, and are simultaneously scheduled for an arthroscopic intervention. The patients are re-evaluated a couple of days before the scheduled date of arthroscopy to determine whether they are still candidates for a surgical intervention or whether the conservative treatment has been sufficient to alleviate the problem. Only patients failing to demonstrate a tendency towards improvement are advanced to arthroscopy.

Arthroscopic lysis and lavage was performed under general anaesthesia with nasoendotracheal intubation. A 2.4-mm 30° arthroscope (Karl Storz GmbH, Tuttlingen, Germany) was inserted into the posterior recess of the superior joint compartment and a 1.9-mm blunt obturator was inserted into the anterior recess of the superior joint compartment. Under direct visualization, the obturator was used to mobilize the articular disc in all directions and stretch the synovial membrane attaching the disc at its junction with the anterior synovium, the retrodiscal lamina, and the medial synovial drape, increasing the disc mobility. The junction of the anterior synovium and disc was fully stretched with the blunt obturator up to the point where minimal tears in the synovium were evident. All surgeries were performed by the same surgeon (WA), and the procedure took approximately 30 minutes. Roughly 150 ml of isotonic saline solution was used during the procedure.

Arthroscopically, the joint cavity demonstrated various degrees of hyperaemia

and synovitis; however, no chondromalacia or subchondral bone exposure was seen. A few cases demonstrated fine adhesions at the anterior recess. Roofing in the open mouth position was decreased to less than 50%. Before terminating the procedure, the mandible was manipulated to maximum range of motion while under muscle relaxation, and a 2-ml intra-articular injection of a solution composed of 1 ml of dexamethasone (4 mg/ml) and 1 ml of bupivacaine (5 mg/ml) was administered along the junction between the disc and anterior synovium.

Patients rehabilitated with the gradual programme were instructed to perform hinge-only movements during the first postoperative week to allow the resolution of oedema and pain. In the second postoperative week, patients started performing opening stretches with the use of stacked wooden spatulas. They were requested to increase the number of spatulas by one or two per day. The purpose of the gradual increases was to prevent overstretching of the tissues, which could worsen the inflammatory process and increase pain. From approximately the third postoperative week onwards, the patients started performing the full range of motion stretch (FROMS) self-exercise (Table 1). The FROMS self-exercise involves stretching the mandible in all directions: vertical (opening), horizontal (protrusion), and transverse (lateral). One cycle of the FROMS consisted of an opening stretch held for 15 seconds, protrusive stretch held for 5 seconds, and right and left lateral stretches each held for 5 seconds. Three cycles were defined as a single set of FROMS; a set was intended to be performed in less than 2 minutes.

Thus, patients rehabilitated with the gradual programme started performing the FROMS self-exercise only from the third postoperative week, at a rate of five times a day (Table 2). In contrast, patients in the immediate group initiated the FROMS self-exercise routine immediately after surgery, starting in the recovery room (Table 2). They were not allowed a period of hinge-only movements or a period of gradual increases in range of motion; rather, they were instructed to perform a set of FROMS exercises immediately after surgery. The exercise routine was performed every hour during the first postoperative week and then in a descending fashion for the remaining weeks: every 2 hours in the second postoperative week, every 3 hours in the third postoperative week, and so on until the sixth postoperative week (Table 2). All patients (in both groups) were advised to continue once-daily FROMS self-exercise for maintenance until week 10–12 postoperative. The self-exercise was performed at each follow-up examination, and was re-taught as needed.

Table 1. Technique for the full range of motion stretch (FROMS) self-exercise[a].

Direction of the stretch	Description of the technique
Vertical stretch (Opening)	• The patient slowly opens the mouth as wide as possible and inserts stacked wooden spatulas approximately 40 mm thick between the upper and lower incisors. The mouth is held open for approximately 15 seconds. • Initially the patient is allowed to perform a purely assistive movement in which the wooden spatulas are pressed against the incisors to aid mouth opening. Gradually the patient is instructed to actively open the mouth rather than resting' on the wooden spatulas; during the exercise, the wooden spatulas should be freely movable in and out while the mouth is held open. If the patient fails to actively open the mouth to the desired extent independently, then he/she is instructed to start the exercise isometrically by slightly opening the mouth several times and resisting the movement with upward pressure on the lower border of the chin (by the hand), and then immediately opening without the hand's resistance and inserting the stacked wooden spatulas.
Transverse stretch (Lateral excursion)	• The patient actively moves the mandible laterally as much as possible. Initially the exercise may be assisted by the patient's fingers further pressing against the chin in the direction of the excursion. The lateral position is held for approximately 5 seconds on each side. • If the patient fails to demonstrate improvement in magnitude of active lateral excursion towards the unaffected side or continues to deviate to the affected side upon opening, the patient is instructed to perform the exercise isometrically by placing two fingers on the chin on the side of the movement and gently counteracting the lateral movement of the mandible against the pressing fingers. This is followed by assisted lateral excursion.
Horizontal stretch (Protrusion)	• The patient slowly moves the mandible forward. In patients with normal occlusion, the lower incisors should bypass the upper incisors. In patients with increased overjet, the goal should be to reach approximately an edge-to-edge relationship. The protrusive position is held for approximately 5 seconds.

[a] A cycle of FROMS consists of vertical (15 seconds), right transverse (5 seconds), left transverse (5 seconds), and horizontal (5 seconds) stretches. Three cycles of these stretches are defined as a single set of FROMS, and these should be performed in less than 2 minutes.

Both groups underwent the same hands-on guided exercises performed by a certified physiotherapist. The 8- to 10-session course started 1 to 2 weeks after surgery at a rate of once or twice a week, and included several techniques: massage with the application of heat, manual distraction of the joint in the vertical direction, active-assistive exercises aimed at increasing range of motion, and manual resistive exercises to strengthen and re-educate the muscles of mastication. All patients were advised to eat a non-chew diet for 1 month after surgery, and to gradually return to a normal diet in the second postoperative month. In addition, patients were educated to refrain from harmful parafunctional habits, such as gum chewing, nail biting, and other pain aggravating

Table 2. Application of the full range of motion stretch (FROMS) self-exercise.

Gradual programme	Immediate programme
PO week 1: hinge-only opening exercise (×5/day)	PO week 1: FROMS exercise every 1 h
PO week 2: opening stretch exercise with gradual daily increases (×5/day)	PO week 2: FROMS exercise every 2 h
PO weeks 3–6: FROMS exercise (×5/day)	PO week 3: FROMS exercise every 3 h PO week 4: FROMS exercise every 4 h PO week 5: FROMS exercise every 5 h PO week 6: FROMS exercise every 6 h
PO weeks 7–12: FROMS exercise once daily	PO weeks 7–12: FROMS exercise once daily

PO, postoperative.

factors. Furthermore, ergonomic advice and posture correction were given as needed.

Maximum mouth opening (MMO) was measured at baseline and at each follow-up visit as the distance between the upper and lower incisors while the patient actively opens the mouth, without the assistance of the examiner or the use of wooden spatulas. Pain perception was measured at each examination using a 10-cm visual analogue scale (VAS), on which 0 indicated no pain and 10 indicated the worst pain imaginable.

The study was approved by the institutional ethics review board, which waived informed consent. The study conformed to the guidelines of the Declaration of Helsinki.

Statistical analysis

IBM SPSS Statistics version 24.0 software (IBM Corp., Armonk, NY, USA) was used for all statistical analyses. Data are presented as the mean ± standard deviation (SD) values. The two groups were compared using the *t*-test for continuous variables (age and duration of lock) and Fisher's exact test for categorical variables (sex and laterality). The Mann–Whitney *U*-test was used to compare the outcome variables (MMO and pain) between the two groups, and the paired *t*-test was used to compare the changes within each group across the measurement time intervals. Results with a *P*-value of <0.05 were considered statistically significant.

Results

The series consisted of 137 patients (94 female, 43 male) with a mean age of 28 years. The majority of the patients (79%) had unilateral TMJ involvement. The mean duration of locking before arthroscopy was 7.2 ± 6.2 months. Baseline MMO of the study population ranged from 20 mm to 34 mm, with an average of 28.9 ± 3.3 mm. The mean baseline VAS for pain was 7.7 ± 1.8. Sixty-eight patients were included in the gradual group and 69 in the immediate group. There was no significant difference between the two groups regarding any of the previously mentioned variables (Table 3).

The preoperative and postoperative MMO and VAS pain scores are presented in Tables 4 and 5, respectively. At the 1-month follow-up evaluation, the mean MMO in the gradual group had increased by 10.4% reaching 31.9 mm, whereas the mean MMO had increased by 30.1% reaching 36.8 mm in the immediate group. This difference was statistically significant ($P < 0.001$). At the 6-month follow-up evaluation, 12 patients in the gradual group and seven patients in the immediate group had been lost to follow-up. The mean MMO of the gradual group had increased to 33.8 mm, while the mean MMO in the immediate group had increased to 37.8 mm. This difference was also statistically significant ($P < 0.001$). Fewer patients attended further follow-up visits after this time point, and only 42 patients in the gradual group and 38 patients in the immediate group were examined after 6 months. The average MMO at the last follow-up available was 37.1 mm in the gradual group (the mean follow-up time for these remaining patients was 11 ± 4.1 months) and 38.3 mm in the immediate group (the mean follow-up time for these remaining patients was 9.6 ± 2 months). This difference was not statistically significant ($P = 0.103$).

Patients rated their pain level on a 10-point VAS at each evaluation. The mean VAS values in the gradual group were 7.8 at baseline, 6.8 at 1 month, 5.3 at 6 months, and 4 at the last follow-up available (Table 5). The mean VAS values in the immediate group were 7.6 at baseline, 4.9 at 1 month, 3.9 at 6 months, and 3.6 at the last follow-up available. The difference between the two groups was significant only at the 1-month and 6-month evaluations ($P < 0.001$ and $P = 0.005$, respectively). The pain values were comparable at the last follow-up examination ($P = 0.867$).

Changes within each group demonstrated statistically significant improvements in MMO and VAS pain when compared to baseline values in both groups at all time intervals ($P < 0.001$).

Table 3. Characteristics of the study population; results are presented as the mean ± standard deviation values.

	Gradual group	Immediate group	*P*-value
Number	68	69	
Male to female ratio	23:45	20:49	0.584
Age (years)	27.5 ± 10.1 (range 16–54)	28.5 ± 10.3 (range 17–59)	0.549
Bilateral TMJ involvement	25%	17.4%	0.302
Duration of lock before arthroscopy (months)	7.9 ± 5.9 (range 4–24)	6.5 ± 6.6 (range 4–19)	0.210
Postoperative follow-up time (months)	8.2 ± 4.7 (range 4–18)	7.8 ± 2.8 (range 5–11)	0.686
Baseline MMO (mm)	29.2 ± 3.3 (range 20–34)	28.5 ± 3.3 (range 20–34)	0.258
Baseline VAS pain	7.8 ± 1.7 (range 2–10)	7.6 ± 1.8 (range 3–10)	0.713

MMO, maximum mouth opening; TMJ, temporomandibular joint; VAS, visual analogue scale.

Table 4. Comparison of maximum mouth opening (MMO) between the two groups.

	Gradual group	Immediate group	*P*-value
Preoperative	29.2 ± 3.3	28.5 ± 3.3	0.258
1 month PO	31.9 ± 3	36.8 ± 3.7	<0.001
6 months PO	33.8 ± 3.4	37.8 ± 3.7	<0.001
Last follow-up available after 6 months PO	37.1 ± 2.8	38.3 ± 3.4	0.103

PO, postoperative.

Table 5. Comparison of VAS pain values between the two groups.

	Gradual group	Immediate group	*P*-value
Preoperative	7.8 ± 1.7	7.6 ± 1.8	0.713
1 month PO	6.8 ± 2.1	4.9 ± 2.2	<0.001
6 months PO	5.3 ± 2.2	3.9 ± 2.4	0.005
Last follow-up available after 6 months PO	4 ± 1.8	3.6 ± 2.4	0.867

PO, postoperative; VAS, visual analogue scale.

Discussion

This study evaluated two different PT programmes for rehabilitation after TMJ arthroscopy. Both programmes included the same easy-to-perform take-home exercises (FROMS). However the two programmes differed in that the gradual programme aimed to achieve controlled increases in mobility until reaching full range of motion in a matter of 2–3 weeks after surgery, whereas the immediate pro-

gramme consisted of full range of motion mobilizations immediately after surgery. In addition, the immediate programme initially involved more frequent exercises than the gradual programme. Although both groups improved after surgery, the immediate programme was found to be superior to the gradual programme in terms of achieving a significantly more rapid rehabilitation towards regaining satisfactory mouth opening and reducing pain.

The majority of the published post-TMJ surgery PT approaches involve a three-stage protocol, which starts with a period of rest and limited rotational movements to allow rapid and uneventful resolution of the postoperative oedema and pain[1,3,14,28]. The second stage comprises gradual stretching exercises to increase range of motion. Controlled increases are advocated to prevent over-stretching and consequently worsening of the inflammatory process. The final stage is aimed at strengthening and re-training the masticatory muscles to maintain the range of motion already achieved and improve coordination between the muscles and joints. Although large agreement appears to exist between the different authors regarding these protocols, they lack a scientific basis and are actually based on 'common sense' rather than on extensive scientific research results[1].

The main reason for shifting to the immediate programme at the study institution was the finding that the mandible was relatively easily manipulated into full range of motion in the early postoperative days, after the articular disc has been fully mobilized and the attached ligaments and capsule have been sufficiently stretched. Performing PT in these early postoperative days did not seem to require higher doses of analgesics or muscle relaxants. In contrast, delaying full range of motion exercises to a week or more after surgery was found to carry with it a substantial degree of difficulty. Patients treated by the gradual protocol often expressed a feeling of mechanical difficulty while trying to open the mouth, similar to the feeling they had experienced before surgery.

At the arthroscopic level, most of the mechanical restriction is encountered in the anterior recess of the joint. Because of the displacement of the disc, the anterior recess is usually narrowed and much effort is made intraoperatively to negotiate the arthroscope and working cannula into it. In addition, the anterior recess is the place where adhesions are usually encountered. During arthroscopy, the attachment of the anterior synovium to the disc is released, or at least stretched, increasing the mobility of the joint. The effect of lysing the adhesions and stretching or releasing the anterior synovium is evidenced immediately intraoperatively as an increase in the mobility of the joint. The condyle reaches the anterior recess by a translatory movement, and advising the patient to perform only rotational movements for 1 or 2 weeks postoperative carries with it the risk of losing what was achieved arthroscopically, due to re-attachment and fibrotic scarring of the anterior tissues, limiting the mobility of the joint again. The 'released' tissues rapidly heal by reattaching and aberrant scar tissue formation, and the role of PT is to ensure favourable healing in which the path that the condyle is supposed to translate anteriorly remains unimpeded[30–32]. In the authors' opinion, if the anterior recess is not mobilized early postoperative, adhesions will rapidly form, which will probably increase the difficulty encountered during the exercises and prolong the feeling of pain experienced after surgery. Performing full range of motion mobilizations immediately after surgery and maintaining a high rate of mobilizations in the following weeks ensures that the newly created path for condylar translation remains patent, regardless of the naturally occurring postoperative scarring and shrinking of tissues.

On the psychological level, the patient's experience of the immediate gain in range of motion increases their self-motivation and serves to improve cooperation with the exercise regime. The patient's feeling that the joint has been 'unlocked' contributes greatly to the level of motivation and perseverance with the exercises in the subsequent weeks, which forms the basis for the success of this procedure.

The risk of overstretching the healing tissues and increasing the inflammation appeared to be negligible in the present study. The patients were instructed to eat a non-chew diet for 1 month postoperative, and NSAIDs were prescribed for 1–3 weeks, depending on the degree of pain. All patients received a benzodiazepine at night during the first postoperative week. The rationale behind administering a muscle relaxant is the fact that, as long as the condylar range of motion was restricted while in the closed lock condition, the masticatory muscles also functioned under this limitation and consequently became shortened. During postoperative mobilization, in addition to the intra-articular difficulty translating the condyle anteriorly, there is difficulty regaining the full length and stretch of the muscles[36]. As the wounds heal, joint structures stabilize, and muscle length is regained with the lapse of time after surgery, the intensity of pain experienced by the patient diminishes[14].

For a rehabilitative programme to be successful, the patient should be educated prior to surgery on the arthroscopic procedure, PT protocol, diet restrictions, medications, and lifestyle modifications. Patients should be informed that performing the most successful arthroscopic procedure does not exempt them from adhering strictly to the rehabilitative programme, and that the success of treatment depends on both surgery and PT. The surgeon has to make sure the exercises are properly performed, and each exercise should be demonstrated and re-taught at every follow-up visit, as needed. Postoperative evaluations should be frequent and should have a positive motivational effect on the patient. The immediate protocol is intensive and demanding, and the patient's cooperation with it should not be regarded as trivial. The surgeon must assume that these patients, regardless of how motivated they appear before surgery, will have complaints after surgery and will require additional care. The surgeon must demonstrate empathy and at the same time be assertive and clear that the whole treatment will not succeed if the protocol is not strictly adhered to. This is the main reason why the patients are kept hospitalized for the next day: to monitor their hourly exercises and make sure that they are performed correctly.

Due to the prolonged anaesthetic effect of bupivacaine, the first 6–8 hours after surgery are usually pain-free. After this, analgesics should be administered on a regular basis for at least 1 week. Even the best-motivated patient will fail to perform the exercises properly without adequate inhibition of pain. From the authors' experience, peak pain levels are usually encountered on the morning of the first postoperative day, at which time the surgeon should evaluate the patient and motivate them, in addition to demonstrating the self-exercise again.

Several clinical trials have evaluated the natural course of untreated closed lock of the TMJ and have found that approximately one-third of the patients with closed lock will regain full range of motion spontaneously in the months following the locking event[16,37–39]. These patients probably have excellent adaptive mechanisms that enable them to overcome the acute injury in their masticatory system, and demonstrate, at an early stage and without treatment, a clear trend towards improvement. The other two-thirds of the

patients will either continue to suffer from unchanged limitations of mouth opening and pain, even after more than 2 years, or will gain only a modest improvement, usually manifested as a moderate increase in mouth opening with a residual dull pain. As mentioned earlier, all patients seen at the study institution are given a period of at least 5 months of conservative therapy, after which a clinical re-evaluation is made, and only those failing to demonstrate a tendency towards improvement are advanced to arthroscopy. Approximately one-third of the patients at the study institution will exhibit a favourable trend towards improvement and will not receive arthroscopy.

While patients who demonstrate significant improvements after a period of conservative therapy are obviously not candidates for arthroscopy and patients who do not demonstrate any improvement are clearly candidates for arthroscopy, the group of patients with moderate improvement may pose a therapeutic dilemma for the treating clinician. The question is whether to continue following them up (with or without conservative therapy) with the hope of a delayed spontaneous resolution[40–44]. In the authors' opinion there are three disadvantages to this approach[45,46]. The first obvious disadvantage is the delay in achieving resolution. As the results of the present study clearly showed, as early as 1 month postoperatively the patients achieved a within normal range of motion. Even if this was feasible spontaneously, it most certainly would take longer. The second disadvantage of a continued untreated complaint is the risk of a chronic pain state developing in the temporomandibular area, which often becomes independent of the internal derangement and becomes recalcitrant to various treatment modalities. The third disadvantage, which has been demonstrated in several clinical trials, is that delaying the arthroscopic intervention significantly lowers the chances of a successful result. The chances of total resolution of the closed lock are higher when the arthroscopic intervention is performed earlier in the course of disease[9,47,48].

The main strengths of this study lie in the relatively large cohort, the specific and elaborate diagnostic criteria used, and the homogeneity of the surgical procedure. There are, however, some weaknesses, the foremost of which is the retrospective design of the trial; as a consequence there was no control group that did not receive any form of PT after arthroscopy, or alternatively a control group that received only PT without arthroscopy. Another weakness is the large number of patients lost to follow-up after the 6-month evaluation point, which partially limits a thorough interpretation of the results.

In conclusion, the results of this study clearly show that initiating full range of motion mobilizations immediately after arthroscopy brings better results in terms of achieving mobility and decreasing pain than a gradual mobilization protocol that aims to achieve full range of motion in a controlled fashion. After arthroscopy eliminates joint mechanical interferences and gains unrestricted joint movement, PT should start immediately with full range of motion mobilizations. Initially the self-administered exercises should be frequent, and as mobility is established and the risk of anterior recess scarring is diminished over time, the exercise rate should gradually be decreased. The surgeon has a major role during rehabilitation, and the use of the finest arthroscopic instruments, applying the most precise and careful procedures, performed by the most experienced hands, does not exempt the surgeon from being actively involved in the postoperative rehabilitation programme.

Funding

None.

Competing interests

None.

Ethical approval

The study was approved by the institutional ethics review board, which waived informed consent (3714-16-SMC). The study conformed to the guidelines of the Declaration of Helsinki.

Patient consent

Not required.

References

1. Dijkstra PU. Post-operative physical therapy of the temporomandibular joint. In: Stegenga B, de Bont L, editors. *Management of temporomandibular joint degenerative diseases*. Basel, Switzerland: Birkhauser; 1996 . p. 177–89.
2. Wilk BR, Stenback JT, McCain JP. Postarthroscopy physical therapy management of a patient with temporomandibular joint dysfunction. *J Orthop Sport Phys Ther* 1993;**18**:473–8.
3. Waide FL, Bade DM, Lovasko J, Montana J. Clinical management of a patient following temporomandibular joint arthroscopy. *Phys Ther* 1992;**72**:355–64.
4. Dimitroulis G. Outcomes of temporomandibular joint arthroscopy in patients with painful but otherwise normal joints. *J Craniomaxillofac Surg* 2015;**43**:940–3. http://dx.doi.org/10.1016/j.jcms.2015.03.035.
5. Dimitroulis G. A review of 56 cases of chronic closed lock treated with temporomandibular joint arthroscopy. *J Oral Maxillofac Surg* 2002;**60**:519–24. http://dx.doi.org/10.1053/joms.2002.31848.
6. Kaneyama K, Segami N, Sato J, Murakami K, Iizuka T. Outcomes of 152 temporomandibular joints following arthroscopic anterolateral capsular release by holmium:YAG laser or electrocautery. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004;**97**:546–51.
7. Murakami K, Moriya Y, Goto K, Segami N. Four-year follow-up study of temporomandibular joint arthroscopic surgery for advanced stage internal derangements. *J Oral Maxillofac Surg* 1996;**54**:285–90. discussion 291.
8. Abboud W, Nadel S, Yarom N, Yahalom R. Arthroscopy of the temporomandibular joint for the treatment of chronic closed lock. *Isr Med Assoc J* 2016;**18**:397–400.
9. Abboud W, Yahalom R, Givol N. Treatment of intermittent locking of the jaw in Wilkes stage II derangement by arthroscopic lysis and lavage. *J Oral Maxillofac Surg* 2015;**73**:1466–72. http://dx.doi.org/10.1016/j.joms.2015.02.027.
10. McCain JP, Sanders B, Koslin MG, Quinn JH, Peters PB, Indresano AT. Temporomandibular joint arthroscopy: a 6-year multicenter retrospective study of 4,831 joints. *J Oral Maxillofac Surg* 1992;**50**:926–30.
11. Sanders B. Arthroscopic surgery of the temporomandibular joint: treatment of internal derangement with persistent closed lock. *Oral Surg Oral Med Oral Pathol* 1986;**62**:361–72.
12. Chen MJ, Yang C, Zhang SY, Cai XY. Use of coblation in arthroscopic surgery of the temporomandibular joint. *J Oral Maxillofac Surg* 2010;**68**:2085–91. http://dx.doi.org/10.1016/j.joms.2009.04.130.
13. Sorel B, Piecuch JF. Long-term evaluation following temporomandibular joint arthroscopy with lysis and lavage. *Int J Oral Maxillofac Surg* 2000;**29**:259–63.
14. Oh DW, Kim KS, Lee GW. The effect of physiotherapy on post-temporomandibular joint surgery patients. *J Oral Rehabil* 2002;**29**:441–6. http://dx.doi.org/10.1046/j.1365-2842.2002.00850.x.
15. Capan N, Esmaeilzadeh S, Karan A, Dıracoglu D, Emekli U, Yıldız A, Baskent A, Aksoy C. Effect of an early supervised rehabilitation programme compared with home-based exercise after temporomandibular joint condylar discopexy: a randomized controlled trial. *Int J Oral Maxillofac Surg* 2016;**46**:314–21. http://dx.doi.org/10.1016/j.ijom.2016.07.010.

16. Craane B, Dijkstra PU, Stappaerts K, De Laat A. Randomized controlled trial on physical therapy for TMJ closed lock. *J Dent Res* 2012;**91**:364–9. http://dx.doi.org/10.1177/0022034512438275.
17. Minakuchi H, Kuboki T, Maekawa K, Matsuka Y, Yatani H. Self-reported remission, difficulty, and satisfaction with nonsurgical therapy used to treat anterior disc displacement without reduction. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004;**98**:435–40. http://dx.doi.org/10.1016/j.tripleo.2003.11.013.
18. Truelove E, Huggins K, Mancl L, Dworkin S. The efficacy of traditional, low-cost and nonsplint therapies for temporomandibular disorder: a randomized controlled trial. *J Am Dent Assoc* 2006;**137**:1099–107.
19. Austin B, Shupe S. The role of physical therapy in recovery after temporomandibular joint surgery. *J Oral Maxillofac Surg* 1993;**51**:495–8.
20. Rocabado M. Physical therapy for the post-surgical TMJ patient. *J Craniomandib Disord* 1989;**3**:75–82.
21. McNeely ML, Olivo SA, David J. A systematic review of the effectiveness of physical therapy interventions for temporomandibular disorders. *Phys Ther* 2006;**86**:710–25. http://dx.doi.org/10.1007/s00586-010-1518-3.
22. Furto ES, Cleland JA, Whitman JM, Olson KA. Manual physical therapy interventions and exercise for patients with temporomandibular disorders. *Cranio* 2006;**24**:283–91. http://dx.doi.org/10.1179/crn.2006.044.
23. Tuncer AB, Ergun N, Tuncer AH, Karahan S. Effectiveness of manual therapy and home physical therapy in patients with temporomandibular disorders: a randomized controlled trial. *J Bodyw Mov Ther* 2013;**17**:302–8. http://dx.doi.org/10.1016/j.jbmt.2012.10.006.
24. Haketa T, Kino K, Sugisaki M, Takaoka M, Ohta T. Randomized clinical trial of treatment for TMJ disc displacement. *J Dent Res* 2010;**89**:1259–63. http://dx.doi.org/10.1177/0022034510378424.
25. Yuasa H, Kurita K. Randomized clinical trial of primary treatment for temporomandibular joint disk displacement without reduction and without osseous changes: a combination of NSAIDs and mouth-opening exercise versus no treatment. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2001;**91**:671–5. http://dx.doi.org/10.1067/moe.2001.114005.
26. Medlicott M, Harris S. A systematic review of the effectiveness of exercise, manual therapy, electrotherapy, relaxation training, and biofeedback in the management of temporomandibular disorder. *Phys Ther* 2006;**86**:955–73.
27. Michelotti A, de Wijer A, Steenks M, Farella M. Home-exercise regimes for the management of non-specific temporomandibular disorders. *J Oral Rehabil* 2005;**32**:779–85.
28. Wilk B, McCain JP. Rehabilitation of the temporomandibular joint after arthroscopic surgery. *Oral Surg Oral Med Oral Pathol* 1992;**73**:531–6.
29. Zislis M, Wank H, Gottehrer N. TMJ arthroscopy—a preoperative and postoperative rehabilitation protocol. *J Craniomandib Disord* 1989;**3**:218–26.
30. Bertolucci L. Physical therapy post-arthroscopic TMJ management (update). *Cranio* 1992;**10**:130–7.
31. Bertolucci L. Postoperative physical therapy in temporomandibular joint arthroplasty. *Cranio* 1992;**10**:211–20.
32. Uriell P, Bertolucci L, Swaffer C. Physical therapy in the postoperative management of temporomandibular joint arthroscopic surgery. *Cranio* 1989;**7**:27–32.
33. Wilkes CH. Internal derangements of the temporomandibular joint. Pathological variations. *Arch Otolaryngol Head Neck Surg* 1989;**115**:469–77.
34. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, List T, Svensson P, Gonzalez Y, Lobbezoo F, Michelotti A, Brooks SL, Ceusters W, Drangsholt M, Ettlin D, Gaul C, Goldberg LJ, Haythornthwaite JA, Hollender L, Jensen R, John MT, De Laat A, de Leeuw R, Maixner W, van der Meulen M, Murray GM, Nixdorf DR, Palla S, Petersson A, Pionchon P, Smith B, Visscher CM, Zakrzewska J, Dworkin SF. Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) for clinical and research applications: recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. *J Oral Facial Pain Headache* 2014;**28**:6–27. http://dx.doi.org/10.11607/jop.1151.
35. Abboud W, Givol N, Yahalom R. Arthroscopic lysis and lavage for internal derangement of the temporomandibular joint. *Ann Maxillofac Surg* 2015;**5**:158–62. http://dx.doi.org/10.1053/joms.2001.21002.
36. Hersh EV, Balasubramaniam R, Pinto A. Pharmacologic management of temporomandibular disorders. *Oral Maxillofac Surg Clin North Am* 2008;**20**:197–210. http://dx.doi.org/10.1016/j.coms.2007.12.005.
37. Sato S, Kawamura H, Nagasaka H, Motegi K. The natural course of anterior disc displacement without reduction in the temporomandibular joint: follow-up at 6, 12, and 18 months. *J Oral Maxillofac Surg* 1997;**55**:234–9. http://dx.doi.org/10.1016/S0278-2391(97)90531-0.
38. Sato S, Kawamura H, Motegi K. Management of nonreducing temporomandibular joint disk displacement: evaluation of three treatments. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995;**80**:384–8.
39. Kurita K, Westesson P, Yuasa H, Toyama M, Machida J, Ogi N. Natural course of untreated symptomatic temporomandibular joint disc displacement without reduction. *J Dent Res* 1998;**77**:361–5.
40. Schiffman EL, Velly AM, Look JO, Hodges JS, Swift JQ, Decker KL, Anderson QN, Templeton RB, Lenton PA, Kang W, Fricton JR. Effects of four treatment strategies for temporomandibular joint closed lock. *Int J Oral Maxillofac Surg* 2014;**43**:217–26. http://dx.doi.org/10.1016/j.ijom.2013.07.744.
41. Schiffman EL, Look JO, Hodges JS, Swift JQ, Decker KL, Hathaway KM, Templeton RB, Fricton JR. Randomized effectiveness study of four therapeutic strategies for TMJ closed lock. *J Dent Res* 2007;**86**:58–64.
42. Dodson TB. Article analysis and evaluation: TMJ closed lock symptoms improve, regardless of intervention. *J Evid Based Dent Pract* 2008;**8**:19–21. http://dx.doi.org/10.1016/j.jebdp.2007.12.005.
43. Murakami K. Importance of time as a factor in the management of temporomandibular joint closed lock. *Int J Oral Maxillofac Surg* 2014;**43**:1302–3. http://dx.doi.org/10.1016/j.ijom.2014.07.003.
44. Manfredini D. No significant differences between conservative interventions and surgical interventions for TMJ disc displacement without reduction. *Evid Based Dent* 2014;**15**:90–1.
45. Dimitroulis G. The role of surgery in the management of disorders of the temporomandibular joint: a critical review of the literature. Part 2. *Int J Oral Maxillofac Surg* 2005;**34**:231–7. http://dx.doi.org/10.1016/j.ijom.2004.06.006.
46. Dimitroulis G. Temporomandibular joint surgery: what does it mean to the dental practitioner? *Aust Dent J* 2011;**56**:257–64. http://dx.doi.org/10.1111/j.1834-7819.2011.01351.x.
47. Machoň V, Sedý J, Klíma K, Hirjak D, Foltán R. Arthroscopic lysis and lavage in patients with temporomandibular anterior disc displacement without reduction. *Int J Oral Maxillofac Surg* 2012;**41**:109–13. http://dx.doi.org/10.1016/j.ijom.2011.07.907.
48. Israel HA, Behrman DA, Friedman JM, Silberstein J. Rationale for early versus late intervention with arthroscopy for treatment of inflammatory/degenerative temporomandibular joint disorders. *J Oral Maxillofac Surg* 2010;**68**:2661–7. http://dx.doi.org/10.1016/j.joms.2010.05.051.

Address:
Waseem A. Abboud
Department of Oral and Maxillofacial Surgery
Sheba Medical Center
Tel-Hashomer 5265601
Israel
Tel.: +972 52 6657050
Fax: +972 49502322
E-mail: waseem.abboud@sheba.gov.il