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# IMMEDIATE VERSUS DELAYED PHYSIOTHERAPY PROTOCOL AFTER THE MANAGEMENT OF TEMPOROMANDIBULAR JOINT ANKYLOSIS BY CONSERVATIVE GAP ARTHROPLASTY

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## *ABSTRACT*

**Objective:** The aim of this study was to evaluate the effect of immediate and delayed physiotherapy protocol on the maximum interincisal opening (MIO), pain magnitude during physiotherapy, and rate of re-ankylosis, following the release of temporomandibular joint ankylosis (TMJa) by conservative gap arthroplasty.

**Subjects and methods:** Twenty four patients with TMJa were treated with conservative gap arthroplasty. They were divided into two equal groups: In group 1, physiotherapy was started 24 hours after surgery. In group 2, physiotherapy was initiated after one week postoperative. MIO, pain magnitude by visual analogue scale (VAS), and rate of re-ankylosis were recorded. The values of MIO and VAS of both groups were compared by paired sample *t*-test.

**Results:** Both groups showed significant improvement in MIO. At one week and one month postoperative, MIO showed significant difference between the two groups ($P$-value ≤ 0.05). At the remaining follow-up period, no significant difference was observed. By comparing the VAS of the two groups, it was significant only at the first day of physiotherapy and at two weeks ($P$-value ≤ 0.05). The rate of re-ankylosis was non-significant between the two groups.

**Conclusion:** Maintenance of MIO is less dependent on the starting time of physiotherapy and more indebted to the patient cooperation with a regular physiotherapy protocol. The reduction in the VAS encourages the patients to perform more comfortable TMJ exercises.

**Keywords:** Conservative gap arthroplasty; Physiotherapy; Temporomandibular joint ankylosis (TMJa).

## INTRODUCTION

Temporomandibular joint ankylosis (TMJa) is the fusion of the mandibular condyle to the base of the skull by fibrous, fibroosseous or osseous mass. Restriction of mandibular movements frequently leads to several distressing conditions including facial disfigurement, impaired speech, difficulty in mastication, poor oral hygiene, malocclusion, airway obstruction, and psychological disorders.[1,2] TMJa occurs primarily in the first and second decades of life.[3] Trauma has been considered the most common cause of ankylosis, as it results in hematoma that followed by excessive bone formation.[1] Additional causes include; infection, congenital anomalies, neoplastic lesions, and systemic diseases such as ankylosing spondylitis, rheumatoid arthritis and psoriasis.[4] Also, it may occur after unsuccessful TMJ surgeries.[5,6] According to Sawhney,[7] TMJa is classified into four types: type I, there is extensive fibrous adhesions around the condyle; type II, there is bone fusion only at the outer edge of the joint surface with condylar remodeling and an intact medial pole; type III, there is a bony bridge between the mandibular ramus and the zygomatic arch with medially atrophic and dislocated fragment of the

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former head of the condyle; and type IV, the joint is completely replaced by an ankylotic mass, which is fused to the skull base.

The primary goals of management of TMJa are the re-establishment of joint functions, prevention of re-ankylosis, and restoration of mouth opening[1,8,9] A variety of surgical techniques have been described in the literature including condylectomy, gap arthroplasty, interpositional arthroplasty, mandibular distraction osteogenesis (MDO), and joint reconstruction with bone grafts or joint prosthesis.[1,4,5] Re-ankylosis is considered to be the most frequent complication following these surgical procedures. To be avoided, adequate resection of the ankylotic mass remains the most important step, regardless of the selected surgical technique.[10] Although the ideal width in gap arthroplasty remains controversial, complete removal of the bone adhesion is widely accepted for releasing the ankylosis.[3,11]

Postoperative physiotherapy is considered another important factor in avoiding re-ankylosis.[1] Most physiotherapy protocols[1,3,5,12] are designed to start jaw exercises immediately after release of the ankylosis. But patients during immediate physiotherapy may suffer from intolerable pain, which may lead to inadequate cooperation for active jaw exercises. This non-compliance will lead to reduction in the mouth opening and re-ankylosis. For this reason, many authors prefer to wait for a period of 5 to 7 days for subsidence of pain and edema and to allow initial healing of the soft tissues before starting physiotherapy.[2,3,9,13,14]

To the best of our knowledge, no study has yet investigated the ideal timing to start TMJa physiotherapy. So the aim of this study was to evaluate the effect of immediate and delayed physiotherapy protocols on the MIO, pain magnitude during physiotherapy, and the rate of re-ankylosis, following the management of TMJa by conservative gap arthroplasty.

## MATERIALS AND METHODS

### Study design and population

To address the purpose of this research, a prospective clinical and comparative study was designed and performed to evaluate the effect of immediate and delayed postoperative physiotherapy following the management of TMJa by conservative gap arthroplasty. The study population was composed of 24 patients, who had been presented to the outpatient clinic of the Department of Oral and Maxillofacial Surgery, Faculty of Dental Medicine for Girls branch, Al Azhar University for the evaluation and management of TMJa from March 2014 to January 2018. For enrolment into this study, patients had to fulfill the following inclusion criteria: (1) patients were diagnosed with true TMJa, (2) presence of pre- and postoperative data records, including clinical and radiographic examinations, (3) non-growing adult patients, (4) operations were performed by the same Oral and Maxillofacial team, and (4) a postoperative follow up period for 24 months. Patients were excluded if they were syndromic or medically compromised. Written informed consent was obtained from all patients or their parents if they were below 21 years, and the local ethics review committee of the Faculty of Dental Medicine for Girls at Al Azhar University approved the study.

### Preoperative assessment

A detailed history, clinical and radiographic examinations were performed for every patient. Demographic and clinical parameters were recorded in a standard sheet and included the following: patients' age at the time of surgery, gender, affected joint (unilateral or bilateral), etiology, preoperative MIO, duration and type of ankylosis. Radiographic investigations included orthopantomography (OPG) and computed tomography (CT), to confirm the diagnosis and to determine the type and extension of the ankylotic mass.

**Study variables**

The primary predictable variable was the starting time of the postoperative physiotherapy protocol (immediate or delayed). The patients were randomly categorized into two equal groups. In group 1, physiotherapy protocol was started 24 hours after surgery. In group 2, physiotherapy was initiated after one week postoperative. The primary outcome variables were the intra- and postoperative MIO, pain magnitude during physiotherapy, and rate of re-ankylosis. The secondary outcome variables were the intra- and postoperative complications including bleeding, infection, malocclusion, and facial nerve injuries. The MIO was assessed by measuring the interincisal distance with a Vernier caliper according to the following equation: mouth opening equals interincisal distance plus overbite. In case of development of postoperative anterior open bite (AOB), the actual MIO was determined by subtracting the amount of postoperative open bite. The pain magnitude during physiotherapy was measured by visual analogue scale (VAS).

**Surgical procedures**

Patients were operated on under general anesthesia with fibreoptic-assisted nasotracheal intubation. The ankylosed joint was approached through the pre-auricular incision with temporal extension, as described by Ellis and Zide.[15] After exposure and identification of the ankylotic mass, a Dunn-Dautery retractor was placed on the medial side of the ankylotic bone to protect the maxillary artery. The prominence of the osseous mass was shaved to the flat surface of the ramus. If a cleavage line was found, it was used as a cut plane. If not, an imaginary line through the lower border of the zygomatic arch was considered, and then the ankylotic mass was carefully excised with surgical burs and chisels. After completion of the osteotomy, a round bur was used to remove the ankylosed bone at the upper bone surface and carefully re-shape the glenoid fossa. A conservative gap width of 7 - 10 mm was created between the re-contoured glenoid fossa and the superior edge of the mandibular ramus, without placement of interpositional material. If an intact disc was present, it was used to line the glenoid fossa. Any sharp edges were smoothened with diamond burs and bone file (Fig. 1).

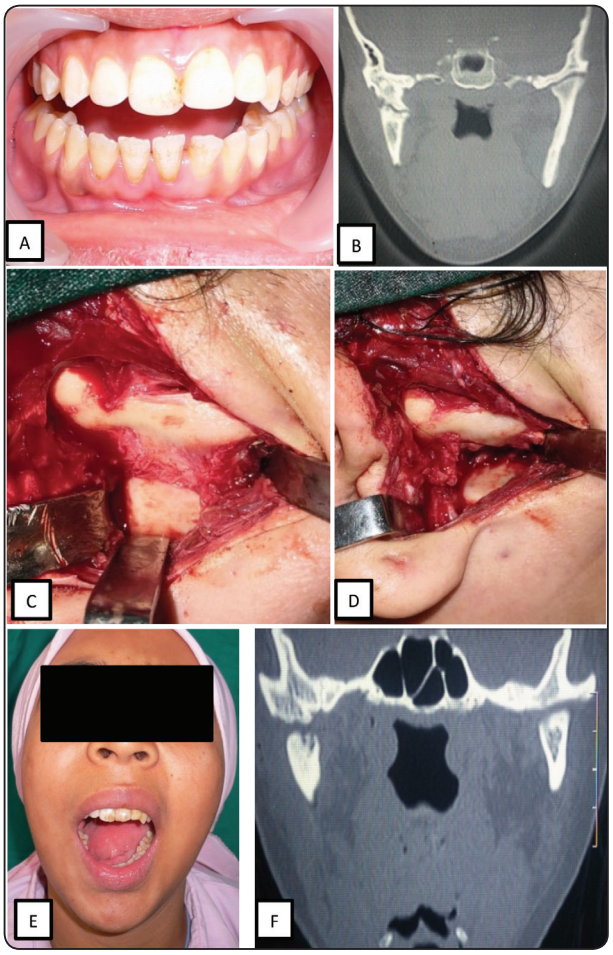


FIG (1) (A) Preoperative photograph showing MIO of 8 mm in a patient with unilateral ankylosis, (B) Preoperative coronal CT scan showing type III bony ankylosis of the right TMJ, (C) Intraoperative image showing exposure of the ankylotic bone, (D) Bony gap after removal of the ankylotic mass, (E) postoperative photograph showing MIO of 39 mm at the end of the follow-up, (F) postoperative coronal CT showing adequate bony gap after 24 months

The transoral temporalis tendon and pterygomasseteric sling were released and the passive MIO was checked intraoperatively. When the coronoid process was either a part of the ankylosis

or too long and the MIO was still less than 35 mm, an ipsilateral coronoidectomy was performed via an intraoral approach. Coronoidectomy was performed at the base of the coronoid process, at the level of the sigmoid notch. In unilateral cases, contralateral coronoidectomy was also considered, if the targeted mouth opening was not achieved by the ipsilateral maneuver. Bilateral coronoidectomy was performed in biltateral cases. Free movements of the mandible were checked again and passive MIO of more than 35 mm was achieved. All wounds were closed in layers and heavily dressed.

**Immediate postoperative care**

Postoperative analgesics and antibiotics were prescribed to control pain, enhance the mouth opening and reduce the rate of infection. Oral feeding was started after extubation with a high protein liquid diet followed by a soft diet for three weeks, and then diet was gradually advanced to a solid consistency. Stitches were removed after one week.

**Physiotherapy protocol**

Before starting physiotherapy protocol, all patients were instructed to perform deep heat therapy and massage to facilitate jaw exercises. Various forms of passive and active jaw exercises were performed for all patients including: (1) mouth opening exercises with the help of a mouth gag, which was opened gradually until the patient retained the achieved intraoperative MIO, and then the mouth gag was replaced with a mouth prop of a suitable size to keep the jaw dilated, (2) active hinge movement, (3) lateral excursions, (4) manual finger stretching in front of a mirror to open the mouth as wide as possible, and (5) gum chewing. Patients were trained and encouraged to continue this protocol at home five times per day, 10-15 minutes for each exercise, for at least six months. In addition, patients were asked to move the chin upwards gently and gradually as much as they can to reach maximum intercuspation, and then keep it for 5 minutes. Physiotherapy was usually performed under supervision for the first 2 weeks, and then by the patient alone. After six months postoperatively, the frequency of physiotherapy was reduced and every patient was instructed to use the mouth gag and mouth prop at least once daily, and to contact the outpatient clinic in case of difficulty in inserting the device.

**Postoperative follow-up**

The patients were seen daily for the first 2 weeks, twice weekly for the remaining of the first month, weekly till six months, every month till the end of the first year, and every three months till the end of the follow-up. In each appointment, patients were evaluated in terms of MIO, pain magnitude during physiotherapy, rate of re-ankylosis, and postoperative complications. Intraoperative and postoperative MIO were recorded at the following times: immediate postoperative before starting physiotherapy, at the end of the first week (i.e. at this time physiotherapy was only started in group 1), one month, 12 and 24 months postoperative. Difference between the pre- and final postoperative MIO was suggested to be the improvement in MIO. At any point in the follow-up period if the MIO was found to be reduced (< 30 mm), forceful jaw opening was performed using a mouth gag under conscious sedation.

Pain magnitude was assessed by VAS (0 to 10, 0 being 'no pain', 10 being 'the most imaginable pain'). It was recorded immediately postoperative (before starting physiotherapy), on the first day of physiotherapy (i.e. 24 hours after surgery in group 1 and one week postoperative in group 2), two weeks, and one month postoperative. All intra- and postoperative complications were retrieved from the clinical records including; bleeding, infection, malocclusion, and facial nerve injury. In addition, re-ankylosis was diagnosed according to the clinical assessment of MIO and imaging data. An MIO of less than 15 mm with bony fusion that was observed on the CT scan, was confirmed as recurrence.[16] Radiographic examination was performed immediately postoperative, at the end of the follow-up, and at any other time if there was evidence of re-ankylosis.

### Statistical analysis

The collected data were recorded, tabulated, and analyzed statistically with Microsoft Office XP (Excel) and SPSS version 15.00 software (SPSS Inc., Chicago, IL, USA). Parametric data were expressed as the mean ± standard deviation (SD), and non-parametric data were expressed as the number and percentage of the total. In every group, MIO and VAS records were analyzed using the ANOVA-test. The same records of the two groups were compared together by paired sample *t*-test. A *P*-value of ≤ 0.05 was considered statistically significant. Pearson's correlation coefficient was used to correlate the effect of demographic data (age and gender) and clinical data (affected side, type and duration of ankylosis) on the MIO, VAS and rate of re-ankylosis. The degree of significance was classified as follows: strong correlation (r > 0.8), moderate correlation (r = 0.5 - 0.8), and weak correlation (r < 0.5).

## RESULTS

### Demographic and clinical data

The present study included 24 patients (29 joints), who had fulfilled the inclusion criteria and had had surgical release of ankylosis by conservative gap arthroplasty. The patients' population consisted of 16 males (66.7 %) and 8 females (33.3 %) with a male to female ratio 2: 1. The patients' age ranged from 16 to 34 years (mean 23.6 ± 5.5 years) at the time of surgery. Most of the patients were in the age group of 16 – 24 years (16 patients, 66.7%). All the patients were followed up for a period of 24 months. The main etiologic factor was facial trauma in 19 cases (79.2 %). The mean duration of ankylosis at the time of presentation was 5.9 ± 2.9 years (range 1-13 years).

Five patients were previously operated once, at other hospitals, for release of TMJa with unsatisfactory results before referral. Nineteen patients (79.2%) had unilateral TMJa, 14 of them were on the right side and 5 on the left side, while bilateral ankylosis was diagnosed in five patients (20.8%), with total of 29 affected sides. Preoperative CT scans identified three sides (10.3% of the total affected sides) had Sawhney type I, four sides (13.8%) with Sawhney type II ankylosis, 10 sides (34.5%) with type III, and type IV affected 12 sides (41.4 %). All these types were confirmed during surgery. The demographic and clinical data of the two groups are presented in Table 1.

**TABLE (1)** Descriptive statistics of the study population

| Study variables | Group 1 | Group 2 | P-value |
|---|---|---|---|
| **Patients number** | | | |
| Gender, n (%) | 12 | 12 | 0.4 |
| Male | 7 (58.3) | 9 (75) | |
| Female | 5 (41.7) | 3 (25) | |
| **Age at operation** | | | |
| Mean± SD (range), years | 22. 5 ± 5.5 (16 - 33) | 24.75 ± 5.2 (16 - 34) | 0.3 |
| **Etiology of the ankyloses** | | | |
| Trauma | 11 | 8 | 0.1 |
| Infection | 1 | 2 | |
| Unknown | - | 2 | |
| **Duration of ankylosis** | | | |
| Mean± SD (range), years | 5.6 ± 3.4 (1-13) | 6.2 ± 2.2 (1-10) | 0.6 |
| **Previous surgery for release of ankylosis** | | | |
| No (primary cases) | 9 | 10 | 0.6 |
| yes (treated once) | 3 | 2 | |
| **Affected side (%)** | | | |
| **Unilateral** | 9 (75) | 10 (83.3) | 0.5 |
| Right | 6 | 8 | |
| Left | 3 | 2 | |
| **Bilateral** | 3 (25) | 2 (16.7) | |
| **Total affected sides** | 15 | 14 | |
| **Sawhney's classification, number of sides** | | | |
| Type I | 1 | 2 | 0.3 |
| Type II | 2 | 2 | |
| Type III | 4 | 6 | |
| Type IV | 8 | 4 | |

*Data presented as mean ± SD or numbers, with percentages in parentheses.*

*No statistically significant difference was found, P-value > 0.05*

**Intraoperative assessment**

Bilateral coronoidectomy was performed in all patients, except three who had ipsilateral coronoidectomy. Intraoperative bleeding was encountered only in four cases (16.7%), three in group 1 and one in group 2. Such complication was controlled by packing.

**Assessment of clinical results**

*Pre-, intra- and postoperative MIO evaluation* (Tables 2 and 3)

In all patients, the preoperative MIO ranged between 0 and 15 mm (mean 6.9 ± 4.2). Both groups showed marked improvement in MIO postoperatively, regardless of the starting time of the physiotherapy. MIO was significantly increased intraoperatively from 7.4±4.8mm to 40.2±2.7mm in group 1 and from 6.5±3.6mm to 40.6±3.1mm in group 2 (*P*-value <0.00001). The MIO measurements were significantly decreased in both groups immediately postoperative (before starting physiotherapy) when compared to the achieved intraoperative MIO with a mean percentage of change -21.6 % in group 1 and -18.1 % in group 2 (*P*-value = 0.001). At one week postoperative, group 1 showed non-significant increase in the MIO more than that reached intraoperatively by 4.5 % (*P*-value = 0.1). On contrary, group 2 showed further decrease in MIO (*P*-value = 0.0002), with a mean percentage of change -25.1 % from that achieved intraoperatively. At one month postoperative, group 1 showed further improvement in MIO than the intraoperative value by 5.2%, without significant difference (*P*-value = 0.054). Also, group 2 showed increase in MIO but still less than the achieved intraoperative MIO (*P*-value = 0.2), as the percentage of change was -3.3 %. When comparing the MIO of the two groups, there was significant difference at one week and one month (*P*-value = 0.00004 and 0.003, respectively).

At the remaining follow-up period, no significant difference was observed between the two groups. At 12 months postoperative, MIO showed significant improvement in group 1 (44±2.9 mm, *P*-value = 0.004). While group 2 showed maintenance in MIO value (42.7±2.5 mm, *P*-value = 0.01). At the end of the follow-up period, both groups showed non-significant reduction in the MIO when compared with the intraoperative values (*P*-value >0.05). It was 37.2±12.2 mm for group 1 with mean percentage of reduction than the intraoperative records by -7.5%, with 10 patients (83.3%) showing values above 35 mm and two patients (16.7%) showed re-ankylosis, as the MIO was 9 and 13 mm. In group 2, the MIO was 36.7±8.2 mm with mean percentage of reduction than the intraoperative records by -9.6%, with 9 cases (75%) showing values above 35 mm and one patient (8.3 %) showed re-ankylosis as the MIO value was 12 mm.

**TABLE (2)** Assessment of MIO during the follow-up period

| | Group 1 | Group 2 | *P*-value |
|---|---|---|---|
| **Preoperative MIO** | 7.4 ± 4.8 (0-15) | 6.5 ± 3.6 (0–13) | 0.6 |
| **Postoperative MIO** | | | |
| Intraoperative | 40.2 ± 2.7 (35-45) | 40.6 ± 3.1 (35-46) | 0.7 |
| Immediate | 31.5 ± 7.1 (20-42) | 33.25 ± 5.8 (22-40) | 0.5 |
| One week | 42 ± 3.1 (36-48) | 30.4 ± 6.8 (18-41) | 0.00004* |
| One month | 42.3 ± 2.2 (37-45) | 39.25 ± 2 (34-42) | 0.003* |
| 12 months | 44 ± 2.9 (39-48) | 42.7 ± 2.5 (37-47) | 0.3 |
| 24 months | 37.2 ± 12.2 (9-47) | 36.7 ± 8.2 (12-45) | 0.9 |

*Data presented as mean ± SD (range) in mm*

** Significant comparison, P ≤ 0.05*

**TABLE (3)** Comparison between intraoperative and postoperative MIO

| | Group 1 | Group 2 |
|---|---|---|
| Intraoperative MIO versus: | | |
| Immediate | 0.001* | 0.001* |
| One week | 0.1 | 0.0002* |
| One month | 0.054 | 0.2 |
| 12 months | 0.004* | 0.1 |
| 24 months | 0.4 | 0.1 |

** Significant comparison, P ≤ 0.05*

**Visual analogue scale assessment (Table 4)**

**TABLE (4)** Assessment of VAS

| VAS | Group 1 | Group 2 | *P*-value |
|---|---|---|---|
| Immediate postoperative (before physiotherapy) | 8.4 ± 1.2 (7-10) | 8.7 ± 1.2 (6-10) | 0.6 |
| First day of physiotherapy | 9.7 ± 0.4 (9-10) | 7.6 ± 1.4 (5-10) | 0.00006* |
| Two weeks | 5.3 ± 1.7 (3-9) | 3.75±1.5 (1-7) | 0.03* |
| One month | 3.25 ± 2.4 (0-8) | 2.9 ± 1.8 (0-7) | 0.7 |
| *P*-value | <0.0001* | <0.0001* | |

*Data presented as mean ± SD (range)*

** Significant comparison, P ≤ 0.05*

Immediately postoperative, all patients had high VAS in the involved joint, ranging from 7 to 10 (mean, 8.4±1.2) in group 1 and 6 to 10 (mean, 8.7±1.2) in group 2, with no significant difference between the two groups (*P*-value = 0.6). At the first day of physiotherapy, in group 1 (i.e. after 24 hours of surgery), the pain magnitude worsened on VAS (mean, 9.7 ± 0.4). On contrary, group 2 (i.e. after one week of surgery) showed improvement in VAS (mean, 7.6 ± 1.4) with significant difference between the two groups (*P*-value = 0.00006). There was significant decrease in pain ratings in both groups at two weeks and one month (*P*-value <0.0001). When comparing the VAS of both groups, its value was still significant at two weeks (*P*-value = 0.03) and became non-significant at 1 month postoperative (*P*-value = 0.7). None of the patients complained of pain during chewing or at rest at the end of the follow-up.

**Postoperative complications**

Postoperative facial nerve weakness was observed in 7 cases (29.2%). The affected nerves recovered completely within three months with nerve physiotherapy and steroids. During the first week postoperative, two patients had infection of the surgical wounds and they were managed with regular wound debridement, sterile dressing, and antibiotic coverage. The infected wounds healed within five days. Gradual decrease in mouth opening (less than 30 mm) was observed in five cases (four in group 1 and one in group 2) within the first three months postoperative and they underwent forceful opening of the mandible using a mouth gag under conscious sedation and then physiotherapy protocol was reinforced on every visit. Signs of re-ankylosis were observed in three patients (two in group 1 and one in group 2) at the end of the follow-up period, which was confirmed by CT examination. The re-ankylosis was observed in patients who had bilateral type IV ankylosis. For those patients, gap arthroplasty was repeated and delayed physiotherapy protocol was re-executed under observation. They were followed up closely with no further complications so far. All bilateral cases showed development of AOB. Light guiding elastics were used for 3 weeks to adjust the occlusion and the patients were instructed to push the chin upward to close the AOB. All the patients were satisfied with the treatment outcomes, except those who developed re-ankylosis. At 12 months postoperative, patients with severe facial asymmetries and mandibular hypoplasia subsequently underwent distraction osteogenesis with or without genioplasty, as a second stage procedure.

On correlating the age of the patients with the MIO at the different time of follow-up periods, a strong and significant correlation was observed in both groups ($P$-value ≤ 0.05). The gender and duration of ankylosis had significant moderate effect on the MIO, while there was no effect of the type and the side of ankylosis on MIO. Regarding the rate of re-ankylosis, there was a negative moderated correlation between the demographic data (age and gender) and the rate of re-ankylosis. On the other hand, there was a weak correlation between the side, duration, and type of ankylosis and the rate of re-ankylosis. Non-significant correlations were observed in both groups, between the demographic and clinical data with the VAS.

## DISCUSSION

TMJa is a gradual process of bony changes in the joint.[17] It was reported that the main causes of TMJa are trauma and infection.[1,4,11,14] Similarly, the current study revealed that trauma was the major cause in 79.2% of the cases and infection only affected 12.5% of the patients. In accord with the findings of many authors,[1,18] the present study showed that patients aged 16 – 24 years, were the most affected age group (66.7%). Many authors observed that females had the highest incidence of ankylosis.[1,19] This is in contrast to the results of this study, as the patients' population consisted of 16 males (66.7 %) and 8 females (33.3 %) with a male to female ratio 2: 1. Male predominance was also reported by others.[3,14,20] Unilateral ankylosis has been reported to be more common than bilateral, with a ratio of 1.5:1.[3,14] The predominance of the lateral side was also observed in this study, with a greater ratio to the bilateral ankylosis (3.8:1). On contrary, Posnick and Goldstein[21] observed that bilateral ankylosis is more common than unilateral in pediatric patients. However, due to the small sample size in this study, no firm conclusions could be drawn.

TMJa can be managed by several techniques; however, no single method has been universally accepted.[9] Gap arthroplasty is the most popular technique because it is simple, less invasive and efficient in restoring mandibular function and achieving satisfactory MIO. Furthermore, the postoperative condition of the patients is more favorable because no donor site is required. Many authors[4,10,22-24] compared the surgical outcomes of gap and interpositional arthroplasty and concluded that both methods showed comparable results regarding the MIO and recurrence rate. Katsnelson et al.[8] compared the range of movement in patients treated by gap arthroplasty and joint reconstruction, and observed better MIO with gap arthroplasty. Many authors observed that restoration of MIO and prevention of re-ankylosis depend mainly on radical resection of the ankylotic mass, aggressive postoperative physiotherapy, and good patient's cooperation with regular follow-up, regardless the selected surgical technique.[11,24-26]

The ideal width of the gap arthroplasty remains controversial. Many authors stated that to prevent re-ankylosis, aggressive bone removal of at least 1.5 cm is required.[1,5,27] However, this wide gap has the disadvantages of creating pseudo-articulation, degenerative changes, shortening of the ramus, malocclusion, suboptimal range of motion, and respiratory distress in bilateral cases.[4,17,22] Furthermore, others claimed that aggressive resection is not essential to prevent re-ankylosis.[3,11,28] Babu et al,[3] observed that a minimum gap of 5–8 mm with complete removal of the mediolateral ankylotic mass is enough to prevent re-ankylosis. According to Temerek[11], a conservative gap of 7-10 mm along the whole width of the ankylotic bone without interpositional material was followed in this study. This conservative gap has many advantages including minimal change in the vertical dimension of the ramus, sufficient gap to prevent re-ankylosis, and adequate remodeling of the ramus stump without the need for TMJ reconstruction.[11]

For the best of our knowledge, there is no published data on the ideal time to start physiotherapy following the gap arthroplasty. Early and aggressive physiotherapy is recommended to disrupt and prevent intra-articular fibrosis, soft tissue contractions, and redevelop normal muscle function, which in turn can regain MIO and prevent re-ankylosis.[1,12,16,29] Following the release of ankylosis, there is usually a period of 2-3 weeks in which the patients are not capable to do active physiotherapy because of pain and swelling and they are blamed for lack of compliance in jaw exercise.[28] Furthermore, the main problem of immediate physiotherapy is that it may induce bleeding and hematoma formation that delays healing and increase the risk of wound breakdown and bone formation.[13] In addition, immediate physiotherapy may lead to excessive strain on the muscles that induces intensive pain during mouth opening; making the patient is less likely to cooperate.[30,31] For this reason, many authors prefer to wait for a period of 5 to 10 days to allow subsidence of pain and edema and allow initial healing of the soft tissues before starting jaw mobilization.[2,3,9,13,14] This waiting period had a great effect on the results of this study, as patients of group 1 cannot tolerate aggressive exercise immediately after surgery, which is reflected by the significant difference of the VAS at the first day of physiotherapy and at two weeks when compared to the patients in group 2 who tolerated the physiotherapy much better (*P*-value = 0.00006 and 0.03, respectively). This is explaining why four patients in group 1 versus one case in group 2, suffered from gradual decrease in mouth opening, during the first three months postoperative. This lack of cooperation was due to the severe pain during physiotherapy, so these patients could avoid such pain by not using the mouth gag, and then they failed to do adequate exercise. Once the decrease in MIO was observed in those patients, aggressive opening under conscious sedation was performed and then the patients were firmly encouraged to perform aggressive physiotherapy with close observation, as also recommended by Shetty et al.[28]

MIO has been considered the main indicator of the success of the gap arthroplasty and the postoperative physiotherapy. In this study, the intragroup comparisons revealed that immediate and delayed physiotherapy were successful in improving MIO during the follow-up period. Whereas, the comparison between the two groups showed non-significant difference during the follow-up period, except at one week and one month postoperative (*P*-value = 0.00004 and 0.003, respectively). This significant difference during the first month is due to the delay of the physiotherapy in the second group. This is in accordance to many authors who stated that the delay in physiotherapy may carry a high risk in losing the achieved intraoperative MIO.[1,3,5,12]. However, because of adequate adherence to the physiotherapy protocol, the intraoperative MIO was successfully restored in group 2 at 12 months postoperative. Furthermore, the MIO records of both groups are comparable (37.2 ± 12.2 mm and 36.7 ± 8.2 mm, respectively) at the end of the follow-up. These final MIO values are in accord to the observation of Danda et al[23] who stated that it is rare to obtain an average MIO of more than 35 mm following the management of TMJa. MIO records of this study are greater than that reported by Roychoudhury et al.[32] and Babu et al.[3] and are similar to the results of Temerek[11], who had MIO of 38 ± 3.8 mm.

Re-ankylosis generally begins with a gradual decrease in MIO, most commonly within the first 12 months after surgery.[33] However, the onset varies from 1 month to as long as 13 years post-operatively (Raveh et al., 1989). In this study, re-ankylosis was reported at the end of the follow-up in three cases (12.5 %), with no significant difference among the two groups. Comparable results were also stated by many authors, who reported 15% of re-ankylosis after gap arthroplasty.[12,24,32] Re-ankylosis in this study was mainly due to lack of compliance with the mouth opening exercises as also reported by many authors explaining that recurrence was mainly related to inadequate performance of physiotherapy

by the patient.[1,30,33] In addition, Cho et al.[34] reported that the narrow gap width, as performed in this study, carries the risk of re-ankylosis. This explaining why both groups showed a decrease in MIO values in the second year of follow-up.

It was believed that the longer the duration of ankylosis, the more aggressive the physiotherapy will be required to maintain adequate mouth opening. Many authors recommended gum chewing, finger stretching and mouth opening exercises for up to one year.[5,22,29] Therefore, it was essential to instruct the patients of this study to continue the jaw exercises for a minimum of six months and to be maintained for two years to prevent recurrence, as also advised by Zhang et al.[30] In addition, the severity of the ankylosis plays another role in the recurrence rate, as many authors observed that relapse usually occurs in Sawhney type IV ankylosis[4,9] and more common in bilateral cases.[35] Similar results were also observed in this study as the three recurred cases are bilateral with Sawhney Class IV.

Considering the effect of the demographic and clinical data on the MIO changes, it was observed that the age and gender as well as the duration of ankylosis showed significant correlation with the MIO during the follow-up period. These findings are in contrast to the results of Khalifa[26] who reported that the demographic and clinical data had no effect on the changes in MIO. On correlating the demographic and clinical data with the VAS, there was no significant effect on the pain magnitude of both groups. Regarding the rate of re-ankylosis, there was only a negative moderate correlation between the demographic data and recurrence rate.

The rate of postoperative complications in the current study was minor. There was temporary mild facial nerve weakness in seven cases, which lasted for three months. Comparable results were also observed by many authors.[1,26] This temporary nerve weakness was mainly due to excessive flap retraction during surgery as reported by many studies.[1,4,32] All nerve weakness in this study occurred in type IV ankylosis, because of the difficulty that encountered during its surgical release that including: long operative time, forceful flap retraction, and greater tissues to be separated. These reasons are also stated by Vasconcelos et al.[4] Postoperative mild AOB is another common complication in bilateral cases. Those patients had an open bite before surgery as a result of muscular pull and the patients' needs to push the food through the anterior teeth as also reported by many authors.[1, 24,32] During the follow-up period, there was an improvement in the AOB and this could be attributed to the narrow gap, the application of light guiding elastics, and the patients were taught to push the chin upwards to close the AOB. This allowed remodeling of the stump of the ramus together with some degree of neuro-muscular reeducation as also reported by Temerek.[11] This is in contrast to the results of Bhatt et al[24] who showed no improvement in the AOB.

The limitations of this study include small sample size and relatively short follow-up period. Different types of ankylosis were included in this study which may affect the eventual outcomes. A study with larger sample size with the same type of ankylosis is recommended to confirm the study outcomes. Long-term follow-up is also needed to document possible recurrence. Nevertheless, strengths of this study include the following: it was a single-institution experience and the study evaluated multiple treatment outcomes. Furthermore, to the best of author's knowledge, this is the first study that assessed the ideal time to start TMJa physiotherapy following conservative gap arthroplasty.

## CONCLUSION

Both early and delayed physiotherapy protocols are successful in restoring and maintaining MIO following management of TMJa by conservative gap arthroplasty. Maintenance of MIO and prevention of re-ankylosis is less dependent on the starting time of physiotherapy and more indebted to the patient cooperation with regular physiotherapy protocol.

The reduction in the VAS encourages the patients to perform more comfortable TMJ exercises, to achieve adequate MIO.

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