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RESEARCH

Can dynamic elastic therapy be established as the standard protocol of closed reduction for moderately displaced extracapsular condylar fractures?

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Abstract

Objective This study was conducted with the aim to establish standard technique of closed reduction (CR) and compare functional outcomes in patients of moderately displaced unilateral extracapsular condylar fractures.

Material and methods This study is a retrospective randomized controlled trial, conducted at a tertiary care hospital setting from August, 2013 to November, 2018. Patients of unilateral extracapsular condylar fractures with ramus shortening < 7mm and deviation < 35° were divided in two groups by drawing lots and were treated by dynamic elastic therapy and maxillomandibular fixation (MMF). Mean and standard deviation were calculated for quantitative variables, and one way analysis of variance (ANOVA) and Pearson's Chi-square test were used to determine significance of outcomes between two modalities of CR. P value < 0.05 was taken as significant.

Results The numbers of patients treated by dynamic elastic therapy and MMF were 76 (38 in each group). Out of which 48 (63.15%) were male and 28 (36.84%) were female. The ratio of male to female was 1.7:1. The mean ± standard deviation (SD) of age was 32 ± 9.57 years. In patients treated by dynamic elastic therapy, the mean ± SD (at 6-month follow-up) of loss of ramus height (LRH), maximum incisal opening (MIO) and opening deviation were 4.6mm ± 1.08mm, 40.4mm ± 1.57mm and 1.1mm ± 0.87mm respectively. Whereas, LRH, MIO and opening deviation were 4.6mm ± 0.85mm, 40.4mm ± 2.37mm and 0.8mm ± 0.63mm respectively by MMF therapy. One-way ANOVA was statistically insignificant (P value > 0.05) for above mentioned outcomes. Pre-traumatic occlusion was achieved in 89.47% of patients by MMF and in 86.84% patients by dynamic elastic therapy. Pearson's Chi-square test was statistically insignificant (p value < 0.05) for occlusion.

Conclusion Parallel results were obtained for both modalities; thus, the technique as dynamic elastic therapy, which promotes early mobilization and functional rehabilitation, can be favored as standard technique of closed reduction for moderately displaced extracapsular condylar fractures. This technique eases patients' stress associated with MMF and prevents ankylosis.

Keywords Mandibular fracture · Condylar fracture · Closed reduction · Open reduction and internal fixation

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Table 1 Indications for open and closed reduction of mandibular condyle fracture AAOMS 2017 guidelines [13]

Closed reduction	Open reduction
• Undisplaced or displaced condylar or comminuted fracture (in growing children) where form and function can be restored	• Dislocated condyle and where there are mechanical interferences with the mandibular function
• No medical contraindications for MMF	• Loss of anterior-posterior and vertical dimension that cannot be managed by closed reduction (ex-panfacial and in edentulous fracture)
• Medical and anesthetic contraindications for open reduction	• Compound fracture
	• Displacement of condyle into middle cranial fossa
	• Patient and surgeon preference for early or immediate mobilization of function

Introduction

Mandible is the second most common adult facial bone that fractures in the maxillofacial area, comprising 15.5–59% of all maxillofacial fractures [1]. Mandible can be fractured at the symphysis, para-symphysis, body, angle, ramus, condyle, coronoid and dentoalveolar regions. The fracture of these anatomical sites has been correlated to mechanism of injury by many studies [2]. The thinnest part of the mandible is the condyle. The proportion of condyle fractures accounts for 17.5–52% of all mandible fractures [3]. Fracture of the mandibular condyle is defined as any fracture which is located above the mandibular foramen and runs from within or above the angle of the mandible into the sigmoid notch or the condylar head [4]. Condylar fractures can be extracapsular or intracapsular, undisplaced, deviated, displaced or dislocated [5]. It can occur by direct or indirect trauma, and the displacement of the fracture is determined by direction, degree, magnitude and the precise point of application of the force, as well as state of dentition and occlusal position [6]. The consequences of condyle fractures range from esthetic compromise to functional impairment such as limited mouth opening, facial deformity, TMJ disorders, malocclusion and ankylosis, in turn affecting the physiological and mental health of patient [5]. Thus, the role of timely competent intervention for management of mandibular condyle fractures cannot be negated [7]. The success of intervention will depend on anatomical reduction of fractures, normal range of mandibular motion, occlusion and absence of postoperative pain [8]. The principal treatment modalities for management of condyle fractures are non-surgical and surgical. Nonsurgical options include conservative management (analgesia, soft diet and clinical monitoring) and closed reduction (CR) with rigid or elastic maxillomandibular fixation (MMF). Whereas, surgical management is based on endoscopic or open reduction and internal fixation (ORIF) [9]. This brings us to the ongoing dilemma since decades, about the right choice of treatment for mandibular condyle fractures [10]. Several studies have endorsed CR as first line of management for condyle fractures, considering its non-invasiveness as compared to potential complications of surgical treatment [11], while many surgeons may now consider ORIF as the “golden standard” for both displaced or dislocated condylar head and neck fractures in adults [12]. However, according to AAOMS 2017 the indications for CR and ORIF of mandibular condyle fractures are listed in Table 1 [13]. Also, absolute and relative indications for ORIF by Zide and Kent are given in Table 2 [13].

According to Asim et al., CR should be only restricted to cases with loss of ramus height (LRH) less than 2mm and less than 10° of deviation of mandibular condyle. Whereas, LRH more than 7mm and condylar deviation more than 35° mandate ORIF [14–16]. Even with these clarities about treatment of condyle fractures provided by literature, we again reached the point of controversy in situations when moderate category cases present, those with LRH between 2 and 7mm and deviation between 10 and 35° [17].

Table 2 Zide and Kent’s criteria for open reduction and internal fixation (ORIF) of condylar fractures [13]

Absolute indications	Relative indications
• Displacement of condyle into the middle cranial fracture	• When intermaxillary fixation is contraindicated for medical reasons
• Impossibility of restoring occlusion	• Bilateral fracture with open bite deformity
• Invasion of foreign body	• Bilateral fracture with associated comminuted mid face fracture
• Lateral extracapsular displacement	• Periodontal problems and loss of teeth
	• Unilateral condylar base with unstable base

A systematic review suggests considerable diversity in the protocols of CR with multiple treatment modalities existing in literature for management of mandibular condyle fractures [11]. CR technique for condylar fracture treatment lacks uniform protocols, resulting in heterogenous sequelae. The outcomes of CR technique will be more positive if these standards can be established [18]. Thus, this study aims to assess functional outcomes of moderately displaced unilateral extracapsular mandibular condyle fractures treated by two modalities of closed reduction.

Material and methods

This retrospective randomized controlled trial was conducted at a tertiary care hospital setting from August, 2013 to November, 2018 after permission from institutional review boards of the research and ethics committee (reference no. LMDC/FD/1826/12). Sample size of 76 patients was calculated with 95% confidence level, 1% margin of error and taking magnitude of mean shortening of ramus length 5.75 ± 4.4mm in patients with unilateral mandibular condyle fractures after closed reduction, as post-operative ramus shortening influences all functional and esthetic outcomes of condylar fracture [19]. Written informed consent was taken from all participants of study with information about need for 6-month follow-up. Ascending ramus height was calculated on OPG by using the method described by Palmieri et al. [20]. A horizontal reference line was drawn through both gonial angles, and a tangent to the superior point of the condyle measured along the ramus indicated the height of the ramus. LRH was calculated by subtracting the ramus height on fractured side from non-fractured side. Deviation of condyle on fractured side was calculated by the angulation between the midline axis of the displaced superior fragment and the midline axis of the caudal fragment, assessed on posteroanterior (PA) view of mandible. Vertical and angular measurements on orthopantomogram (OPG) are acceptable provided the patient's head is positioned properly in the equipment, whereas, horizontal measurements tend to be unreliable because of nonlinear variation in magnification at different object depth [21]. Radiograph was taken by single technician, complying with the regulations and guidelines of clinical trials, including good clinical practice (GCP) guidelines [22, 23].

Inclusion criteria of study was as follows:

1. Patients between age 18 and 50 years of both genders
2. All unilateral, displaced extracapsular condylar fractures with (angle ≤ 35°) on PA view of mandible and ramus shortening ≤ 7mm on OPG.
3. Sufficient dentition to reproduce the occlusal relationships.
4. Patient's consent to participate.

Exclusion criteria of study was:

1. All patients that conformed to the criteria of Zide and Kent for absolute and relative indications of ORIF.
2. Patients with pre-existing pathological conditions of temporomandibular joints on history and radiographs.
3. Patients in which closed reduction is contraindicated such as mentally unstable or uncooperative patients.
4. Unilateral condylar fractures associated with other facial or mandibular fractures.
5. Unilateral condylar fractures with history of trauma > 2 weeks

   All patients excluded from study had surgical treatment.
6. Patients who did not present for 6-month follow-up were excluded from study.

After obtaining informed written consent from participants, demographic data regarding name, age, gender, contact details, followed by history of trauma, time elapsed since fracture and medical history were recorded. Patients were then clinically and radiographically assessed. To ensure randomization, selection of patients for the two treatment modalities was done by opening lots in sealed envelope.

Group A comprised of patients treated by dynamic elastic modality. Erich's arch bar was secured on maxillary and mandibular arch with 26-gauge stainless steel wire under local anesthesia (2% lignocaine with 1:100,000 epinephrine).

Phase 1: Elastics 6.5-oz $^{3}/_{16}$ -inch were placed (Class II ipsilateral to fracture, class I contralaterally) for 2 weeks. Class III elastics were placed on contralateral side to injury in case of severe displacement. Patients were placed on liquid diet.

Phase 2: After 2 weeks, centric occlusion and opening deviation were assessed, and elastics 6.5-oz $^{1}/_{4}$ -inch were placed class I bilaterally, in case of no discrepancy. Otherwise, initial orientation of elastics was continued for another week. The orientation of elastics and the number of luges engaged was adjusted based on intercuspation and opening deviation.

Phase 3: From fifth week onward, all patients were advised mouth opening exercises and lateral excursions under guidance of elastics. Duration of treatment was approximately 6 weeks. Post-operatively all patients were advised physiotherapy three times a day for 2–3 months until significant mouth opening was achieved.

Patients allocated in group B were treated by maxillomandibular fixation (MMF). In this technique, Erich's arch

Table 3 The mean and SD of post-operative outcomes between two groups at 6-month follow-up

Post-operative outcome	Groups	Mean ± standard deviation
Loss of ramus height (on fractured side)	Group A	4.6mm ± 1.08mm
	Group B	4.6mm ± 0.85mm
Maximum inter-incisal opening	Group A	40.4mm ± 1.57mm
	Group B	40.4mm ± 2.37mm
Mandibular deviation on opening	Group A	1.1mm ± 0.87mm
	Group B	0.8mm ± 0.63mm

bar was secured on maxillary and mandibular arch in same way as Group A.

Phase 1: MMF was done using 26-gauge stainless steel wire for 2 weeks, and patients were advised liquid diet.

Phase 2: After 2 weeks, 6.5-oz $^{3}/_{16}$ -inch elastics were placed in patients (Class II ipsilateral to fracture, class I contralaterally), if no deformity was noted, with continuation of blended liquid diet.

Phase 3: After total treatment time of 4 weeks, supportive elastics were placed in class I orientation bilaterally for 7–10 days. If patients showed any discrepancy in occlusion and opening deviation in these stages, then orientation of elastics in that stage was maintained for another week. This was followed by physiotherapy three times a day for 2–3 months until significant mouth opening was achieved.

Postoperatively, clinical and radiographic evaluation was performed by single observer, who was blinded to groups. Patients were advised OPG and PA view of mandible at 6-month postoperative follow-up. At this appointment, ascending ramus height was calculated on the fractured and non-fractured sides by using trace paper and ruler. Comparison of ramus height was done between two sides of mandible and LRH calculated. Assessment of outcomes of MMF and dynamic elastic modalities was also part of this follow-up appointment. The maximum inter-incisal opening (MIO) was the distance between incisal edges of maxillary and mandibular central incisor teeth on maximal mouth opening, measured by ruler. Estimation of midline discrepancy from facial midline was done to signify deviation of mandible on mouth opening, whereas, post-operative malocclusion was assessed by Singh V and colleagues modified scoring method (i.e. 1: Pre-trauma occlusion. 2: Mild malocclusion that required occlusal adjustment by spot grinding of teeth, 3: Gross malocclusion that required ORIF). Data analysis was performed using Microsoft excel for Mac version 16.56 (2021 Microsoft). Mean and standard deviation were calculated for quantitative variables like age, loss of ramus height (LRH), MIO and deviation of mandible on opening. One-way analysis of variance (ANOVA) was applied to determine which of the two modalities of closed reduction had significant impact on post-operative LRH, MIO and mandibular deviation. Pearson's Chi-square test was used to explore the association between two techniques and occlusion. P value $\leq$ 0.05 was considered significant.

Results

The numbers of patients treated for moderately displaced unilateral extracapsular condyle fractures by two different techniques of CR were 76. Out of which 48 (63.15%) were male and 28 (36.84%) were female. The ratio of male to female was 1.7:1. The mean ± standard deviation (SD) of age was 32 ± 9.57 years. The mean and SD of post-operative outcomes at 6-month follow-up are given in Table 3.

One-way ANOVA was applied to determine association between dynamic elastic and MMF techniques of CR with post-operative outcomes. The association of LRH, MIO and mandibular deviation with two techniques of CR was statistically insignificant p value > 0.05 as shown in Tables 4, 5 and 6 respectively. Pearson's Chi-square test

Table 4 One-way ANOVA between two treatment modalities of closed reduction and ramus shortening was insignificant, P value > 0.05

Groups	*Count*	*Sum*	*Average*	*Variance*		
Dynamic elastic technique	38	175	4.60526316	1.17780939		
MMF technique	38	176	4.63157895	0.7254623		
ANOVA						
Source of variation	*SS*	*Df*	*MS*	*F*	*P value*	*F crit*
Between groups	0.01315789	1	0.01315789	0.01382661	0.90671381	3.97022958
Within groups	70.4210526	74	0.95163585			
Total	70.4342105	75				

Table 5 One-way ANOVA between two treatment modalities of closed reduction and maximum incisal opening was insignificant, *P* value > 0.05

Groups	*Count*	*Sum*	*Average*	*Variance*		
Dynamic elastic technique	38	1534.5	40.3815789	2.46532717		
MMF technique	38	1536.5	40.4342105	5.65096017		
ANOVA						
Source of variation	*SS*	*Df*	*MS*	*F*	*P value*	*F crit*
Between groups	0.05263158	1	0.05263158	0.01296937	0.90963883	3.97022958
Within groups	300.302632	74	4.05814367			
Total	300.355263	75				

was used to find relation between post-operative occlusion and two treatment techniques. *P* value was again insignificant.

Discussion

There are many studies in literature comparing anatomical reduction, functional outcomes as well as quality of life after CR and ORIF techniques of mandibular condyle fracture management [8, 9, 12, 24, 25]. Function as defined by dictionary Webster (Merriam-Webster, 1970) is "designed or developed chiefly from the point of view of use." Thus, functional outcomes are those results which allow a person to participate purposefully in various life activities [26]. The indications for CR and ORIF have been defined by literature, [13] but there still exists a controversial case presentation scenario of unilateral mandibular condyle fractures, with post-trauma LRH between 2 and 7mm and condylar mediolateral deviation between 10 and 35°. This scenario can be characterized as moderately displaced mandibular condyle fracture. In this scenario, both CR and ORIF techniques have been used by surgeons for management of adult mandibular condyle fractures [27]. Rastogi et al. [28] and Danda et al. [29] found that there is no significant difference between the outcomes of CR and ORIF. Rozeboom et al. also reported good outcomes with both techniques in moderately displaced mandibular condyle fractures [30]. Generally, it is always preferred to avoid surgery and its complications; additionally, ORIF is associated with expensive hardware, hospitalization, long general anesthesia time and sick leave costs [30].

There is also variation in literature regarding type of CR technique used [31] like intermaxillary fixation followed by functional follow-up, dynamic elastic therapy or functional treatment [31–33]. In developing countries like ours, many people cannot withstand the treatment cost for ORIF. Therefore, this study was conducted to compare two techniques of CR, in order to establish a uniform protocol of CR that provides better functional outcomes.

The mean LRH on fractured side with dynamic elastic therapy and MMF were 4.6mm ± 1.08mm and 4.6mm ± 0.85mm respectively. Kobayashi et al. reported LRH for unilateral condylar fractures treated by MMF and measured on 3D-CT as 4.1mm ± 3.1mm [34] which coincides with results of our study. Contradictory to this study, Eckelt et al. reported 5.75mm ± 4.4 mm [24], and Singh et al. reported 5.68mm ± 2.93mm [35] of LRH with MMF technique. LRH reported by Khiabani et al. [36] (5.30mm ± 0.75mm) with dynamic elastic therapy also differs from our study.

The mean MIO after dynamic elastic therapy was 40.4mm ± 1.57mm and after MMF was 40.4mm ± 2.37mm. These findings depict that adequate MIO was achieved with both techniques, as mouth opening >35mm is considered a successful outcome according to literature [9, 37–40]. Similar finding was also reported by Eckelt et al. (40.9mm ± 6.7mm) by MMF [24]. Contrary to results of this study, Singh et al. reported MIO at 6 months to be 33.54mm ± 1.89mm [35], and Rozeboom et al. stated 53.3mm ± 7.4mm [30] by MMF. With dynamic elastic therapy, Niezen et al. reported higher post-operative

Table 6 One-way ANOVA between two treatment modalities of closed reduction and mandibular opening deviation was insignificant, *P* value > 0.05

Groups	*Count*	*Sum*	*Average*	*Variance*		
Dynamic elastic technique	38	43.5	1.14473684	0.75551209		
MMF technique	38	32	0.84210526	0.39331437		
ANOVA						
Source of variation	*SS*	*Df*	*MS*	*F*	*P value*	*F crit*
Between groups	1.74013158	1	1.74013158	3.02940721	0.08592462	3.97022958
Within groups	42.5065789	74	0.57441323			
Total	44.2467105	75				

MIO inconsistent to this study as 52.6mm [41], while MIO reported by Khiabani et al. [36] (44mm ± 2.31mm) coincides with the current study.

Deviation on mandibular opening in this study after MMF (0.8mm ± 0.63mm) coheres with Singh et al. (1.18mm ± 1.29mm) [35] and Asim et al. (1.09mm ± 1.60mm) [16]. In contrast, Eckelt et al. reported higher deviation (3.1 mm) [24]. Whereas, mandibular deviation by dynamic elastic therapy in this study was 1.1mm ± 0.87mm, which is close to 0.8 ± 3.61 reported by Khiabani et al. [36].

Pre-traumatic occlusion in this study was achieved in 89.47% of patients by MMF, close to findings of Rozeboom et al. (91.7%) [30], Madadian et al. (90.96%) [9] and Singh et al. (91%) [35]. A systematic review reported that recovery of occlusion is between 76 and 100% by MMF [11]. Whereas, current study reveals that pre-traumatic occlusion after dynamic elastic therapy was observed in 86.84% of patients. In contrast, Niezen et al. reported occlusal discrepancy in 76% of patients by functional therapy [42].

Considering the limitations, a larger sample size with longer follow-up may yield significant outcome. Further comparisons with open reduction and internal fixation technique for treatment of moderately displaced unilateral/bilateral extracapsular condylar fracture can broaden the scope of the study.

Conclusion

The close treatment techniques analyzed in this study are based on limited period of fixation of jaws versus functional treatment. Outcomes of both techniques turned out to be very similar in all parameters compared. Therefore, priority should be given to technique that promotes function, as early mobilization of jaw is recommended, thus warranting functional rehabilitation. Moreover, longer period of fixation is associated with increased risk of ankylosis with intracapsular, extracapsular and displaced fractures [43]. Also, there is a recent shift of trend towards less rigid fixation and more functional techniques.

Author contribution All authors contributed to study conception and design. Material preparation and data collection were performed by FAC, FA and TR. Data analysis and first draft of manuscript was written by SM. Critical review was done by AS and NZ. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Lahore Medical & Dental College (reference no. LMDC/FD/1826/12).

Consent to participate Written informed consent was obtained from all individual participants included in the study.

Consent for publication This study does not contain any individual person's data in any form (including individual details, images or videos).

Competing interests The authors declare no competing interests.

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