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Meta-Analysis and Systematic Review: Open Reduction Internal Fixation (ORIF) Vs Closed Reduction (CR), out of two which is more Favourable for Treating Mandibular Condylar Fracture

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ABSTRACT
Condylar fracture are most common fractures of mandible. But there exits a years old controversy of the treatment, either to treat it by open reduction internal fixation or by functional means i.e. closed reduction. Traditionally condylar fracture were treated by closed reduction, nowadays the trend is for open reduction and internal fixation. Both the treatment has its own merits and demerits. This meta-analysis and systematic review compare the outcome of the condylar fractures treated by open reduction and internal fixation and closed reduction in terms of maximum incisal opening, lateral excrusion, protrusion.

INTRODUCTION

Mandibular fractures are the most common facial fracture. Mandibular condylar fractures are the most common mandibular fractures, with an overall incidence of 18-57% and incidence of 24-72% in children. Mandible fractures are more common in males and common causes of traumatic facial injury include motor vehicle accidents, violence, sports-related trauma, falls and industrial incidents.

Condylar fractures are classified according to the anatomic location and the degree of dislocation of the articular head. There are 2 methods of principal therapeutic modalities to these fractures functional and surgical. There has been considerable controversy regarding the treatment of condylar fractures, either they should be treated conservatively or surgically. There are complications associated with both types of treatment.

As children may sustain minimal condylar process fractures and because they have an increased ability for bone regeneration and remodelling, numerous studies have reported favourable results following closed reduction (CR) in children. CR is mostly performed by stabilizing the fracture site using a lingual splint and circum-mandibular wires, intermaxillary fixation with arch bars or interdental fixation, or maxillomandibular fixation. However, totally dislocated or commuted fractures may require open reduction and internal fixation (ORIF) to obtain optimal realignment.

The best treatment strategy, that is, closed reduction or open reduction and internal fixation, remains controversial Santler *et al*.[1]. Closed treatment has been the preferred treatment for several years; however, long-term complications include open bite, pain, inadequate restoration of vertical height of the ramus, arthritis and deviation of the mandible Singh *et al*.[2]. A better understanding of the sequelae associated with closed treatment has resulted in a trend toward open treatment, allowing anatomical repositioning and internal fixation and enabling functional aftercare Sawhney *et al*.[3], Stiesch-Scholz et al.[4].

This study performed a meta-analysis of studies comparing the open and closed treatment of mandibular condyle fractures.

MATERIALS AND METHODS

Search approach: Articles for the studies were searched using keywords like "Mandibular Condyle fracture", open vs closed treatment" from electronic databases like Cochrane Library, PubMed, EMBASE, and Medline. Articles were also searched in google scholar and Clinical Trials Registry. The titles and abstracts of each article were reviewed initially by one author and thereafter by two more authors and studies that satisfied all of the eligibility criteria were included in this systematic review after mutual agreement between the authors.

Result of search: Articles were searched on electronic databases like Pubmed, Cochrane, Embase by keywords like "open vs closed treatment of mandibular condylar fracture". A total of 16500 articles were found by searching through google scholar. Then, after removing duplicates and articles with irrelevant contents, 49 articles were procured which were then screened further. In the next steps, 28 articles were excluded based on inclusion and exclusion criteria which left a total of 19 articles to be included in the final quantitative analysis.

Inclusion criteria:

- Eligibility criteria included studies published in English including human studies
- The studies had to be conducted on patients who have CMFs, being displaced, undisplaced, unilateral, bilateral, or multiple
- The study could have applied CTR and ORIF
- Randomized controlled clinical trials, cohort studies, case control studies, cross-sectional studies and case series were included

Exclusion criteria:

- Single case reports and review articles without original data were excluded, although references to potentially pertinent articles were noted for further follow-up
- Only articles in which comparison of open vs closed treatment were done. Articles including only open or only closed treatment are excluded
- Follow up less than 6 months were excluded from the study
- Patient more than 90 years of age were excluded in the study

Selection of studies: Full articles were thoroughly reviewed by two authors in two phases. In the first phase articles with relevant titles and abstracts were searched and from them, irrelevant, duplicates, etc. were removed. After this, Articles that were relevant with full text and in the English language were selected for screening in the second phase. In the second phase, the articles which were selected in the first phase were screened for inclusion and exclusion criteria and after thorough processing, relevant articles were selected for statistical analysis.

Data extraction: The extraction of data was performed in two stages. In the first stage of data extraction, the following data were extracted author, year of publication of articles, sex distribution, type of analysis (patients and fractures), mean age, and the main cause of mandibular fracture. In the second stage the following data were extracted comparison of open vs closed reduction for treatment of mandibular condylar fractures in terms of mouth opening, mandibular movements deviation, occlusional disturbances in terms of mean difference Review Manager Software ver.5.4.1 was used for the computation of data and forest plots and funnel plots were made.

Statistical analysis: Information regarding the mandibular condylar fracture treatment in order to compare the outcome of closed or open method is better was extracted from each of the included studies and the mean difference, standard deviation of various variables used in order to compare the outcome the treatment either open or closed. A random effects model was used.

RESULTS

The data extracted from the 19 studies have been tabulated in various tables
mentioned below:

Data obtained from several articles like "author's name, year of study, place of study, Cases and controls mentioned in the respective studies, mean difference with standard deviation of maximum interincisal distance in open vs closed treatment of mandibular condylar fracture, p-value" has been shown in table 1.

Data obtained from several articles like "author's name, year of study, place of study, Cases and controls mentioned in the respective studies, mean difference with standard deviation of protrusion movements in open vs closed treatment of mandibular condylar fracture, p-value" has been shown in table 2.

Data obtained from several articles like "author's name, year of study, place of study, Cases and controls mentioned in the respective studies, mean difference with standard deviation of excrusion movements in open vs closed treatment of mandibular condylar fracture, p-value" has been shown in table 3.

Data obtained from several articles like "author's name, year of study, Cases and controls mentioned in the respective studies, mean difference with standard deviation of ramal height shortening in open vs closed treatment of mandibular condylar fracture, p-value" has been shown in table 4.

Data obtained from several articles like "author's name, year of study, Cases and controls mentioned in the respective studies, mean difference with standard deviation of deviation from midline in open vs closed treatment of mandibular condylar fracture, p-value" has been shown in table 5.

Data obtained from several articles like "author's name, year of study, place of study, Cases and controls mentioned in the respective studies, mean difference with standard deviation of coronal angulation in open vs closed treatment of mandibular condylar fracture, p-value" has been shown in table 6.

Data obtained from several articles like "author's name, year of study, Cases and controls mentioned in the respective studies, mean difference with standard deviation of sagittal angulation in open vs closed treatment of mandibular condylar fracture, p-value" has been shown in table 7.

As the data collect and according to the forest plot there was no statistically significance between the fractures treated by Open reduction and internal fixation or Closed reduction in terms of incisal mouth opening, protrusion and excrusion movements.

The systematic review do show that the open reduction and internal fixation has better results in terms of ramal height shortening, deviation and sagittal and coronal angulation.

DISCUSSIONS

The temporomandibular articulation, consists of the condylar heads, inter-positional disks, glenoid fossae, and articular eminences. Functionally, these articulations permit a broad range of movement in the mouth opening-closing axis including the glenoid fossa and articular eminence. There are two major movements while opening the mouth, rotational and translational which occur in the inferior and superior compartments, respectively. Mandibular function is characterised as a class III lever with the joint being the fulcrum. The musculature applies the force between the joint and the masticatory load.

Harmonious masticatory system is capable of broad adaptation over time but the sudden alterations produced by condylar fractures can create certain expected typical clinical findings of functional alterations. A patient with a condylar fracture will variably demonstrate one or more clinical alterations in mandibular function like Ipsilateral (Side of Injury) Occlusal Prematurity, Inability to Achieve Maximum Intercuspation, Ipsilateral Laterognathia, Ipsilateral Deviation on Opening, Balancing Side Occlusal Interferences during Contralateral Mandibular Translation, Limitation of Mouth Opening.

The goals of treatment of condylar fractures are to restore function to the preinjury state and to do so with undisturbed healing of the injured site. A patient who has had a condylar fracture cannot be considered to be cured until he is able to masticate easily with the contralateral side of the dentition, which implies the recovery of the condylar excursion. The goals of closed treatment, a more appropriate designation than closed reduction because in most cases no "reduction" of the fracture is performed, include rehabilitation of

Table 1: Maximal incisial opening

Author	Year	country	Cases (surgical)	Control (closed)	Total patient	Mean difference and standard deviation (open)	Mean difference and standard deviation (closed)	p-value
Celso palimieri	1999	Texas	62	74		43.1±10.9	44.6±8.4	xx
Ecklet schiender	2006	Germany	36	30	66	46.5±5.3	40.9±6.7	0.01
G de riu	2001	Italy	20	19		43.7+5.9	46±7	xx
Haug	2001	Lexington	10	10	20	46±9.70	42.50±9.92	0.18
Kohji ishihama	2007	Japan	24	43	67	41.3±8	40.6±6	xx
Santler	1999	Austria	37	113		45.5±7.3	47±6.8	xx
Susan yu chen	2014	Taiwan	20	18		39.50±6.50	34.7±.99	0.048
V singh	2017	India	10	10	20	40.9±1.91	37.8±2.57	<0.01
Anil danda	2010	India	16	16	32	42.125±xx	40.062±xx	0.05
Wen guei yang	2002	Taiwan	36	30	66	33.9±xx	41.8±xx	0.291
Takenoshinta	1990	Japan	16	20	36	50±xx	39±xx	xx

Table 2: Protrusion

Author	Year	Country	Cases (surgical)	Control (closed)	Total patient	Mean difference and standard deviation (open)	Mean difference and standard deviation (closed)	p-value
Celso palimieri	1999	Texas	62	74	136	7.8±2.9	6.8±2.6	xx
Ecklet schiender	2006	Germany	36	30	66	7.3±5.3	4.7±2.5	0.0005
G de riu	2001	Italy	20	19	39	7.4±2.2	6.3±2.5	xx
Haug	2001	Lexington	10	10	20	6.40±3.32	5.10±2.42	0.33
Santler	1999	Austria	37	113	150	5.9±2.3	6.2±2.17	
Susan yu chen	2014	Taiwan	20	18	38	39.50±6.50	34.7±6.99	0.048
V singh	2017	India	10	10	20	1.1±0.82	1.60±1.07	0.27
Stiesch scholz	2005	Germany	24	13	37	112.71±22.8	87.38±17.37	0.001
Worsae	1994	Germany	24	28	52	7±xx	7±xx	0.05
Anil danda	2010	India	16	16	32	8±xx	6.93±xx	0.05
M. hlawitschka	2005	Germany	14	29	43	6.3±XX	7.8±XX	XX

Table 3: Extrusion movements

Author	Year	Country	(surgical)	Control (closed)	Total patient	Mean difference and standard deviation (open)	Mean difference and standard deviation (closed)	p-value
Celso palimieri	1999	Texas	62	74	136	10.1±3.4	9.8±.9	xx
G de riu	2001	Italy	20	19	39	8.6±2.2	8.5±3.5	xx
Santler	1999	Austria	37	113	150	8.5±.3	8.7±3.4	xx
V singh	2017	India	10	10	20	6.7±0.82	4.8±.78	p<0.01
Stiesch scholz	2005	Germany	24	13	37	91.02±43.87	84.18±21.77	xx
Anil danda	2010	India	16	16	32	8±xx	6.5±xx	0.05
Takenoshita	1990	Japan	15	20	35	8.7±3	>6.0±3.8	XX

Table 4: Ramus height shortening

Author	Open Mean±SD	Closed Mean±SD	Open%	Closed%	p-value
M. hlawitschka	-	-	1.3 N = 14	8.2 N = 24	
Kotrashetti	70.50±2.5055	65.3333±5.9135	-	-	0.0183 T- 2.0810
Ekclet 2006	0.31±1.2 mm (N = 36)	5.75±4.4mm N = 30	-	-	
Muhammed shinju rastogi 2015	1.75 mm	3.75 mm	-	-	0.04
V singh 2017	1.1±0.87	11.6±1.5	-	-	<0.05
G de riu >3mm	-	-	0 0/22	9 2/22	
Karthik ragupathy	N = 11	N = 16	0	56.25 9/16	

Table 5: Deviation

Author	Mean±SD Open	Mean±SD Closed	Open%	Closed%	p-value
Meike stiesch scholz 2005	-	-	25 (6/24)	38 (5/13)	0.313
Wen guei yang 2002 <5 mm	-	-	condylar 21.43 (3/14) Subcondylar 22.72 (5/22) If avg:22	condylar 56.25 (9/16) subcondylar 21.43 (3/14) if avg :38.84	0
Celso palmieri edward ellies 1999	1.4±6.1 N = 62	2.3±6.3 N = 74	-	-	0.017
G de riu 2001	-	-	<3mm 30 (6/20) >3mm 10 (2/20)	<3mm 21 (4/19) >3mm 10.5 (2/19)	
Ecklet 2006	2.6 mm N = 36	3.1mm N = 30	-	-	0.03
Muhammad shinju, rastogi			0	70	
Haug 2001	0.50±1.08	0.80±0.92	-	-	0.51
Hidding <3mm	-	-	10 (2/20)	64 (9/14)	
Susan yu chen 2014 >5mm	-	-	5 (1/20)	27.8 (5/18)	0.083
V singh 2010	0.38±0.84 N = 18	1.18±1.29 N = 22	-	-	0.03
Karthik ragupathy	N = 11	N = 16	18 (2/11)	37.5 (6/16)	

Table 6: Coronal angulation

Authors	Mean±SD open (degrees)	Mean±SD closed	open%	closed%	p-value
Celso palmieri edward ellis 1999	3.5±8.2 N = 62	19.5±25.3 N=74	-	-	<0.001
Edward ellies iii 2000	3.44±11.28 N = 35	16.28±21.66 N=31	-	-	<0.001
Wen guei yang 2002	45.46±22.38 N = 22	3.5±2.68 N=14	-	-	<0.001

Table 7: Saggital angulation

Authors	Mean±SD open (degrees)	Mean±SD closed	open%	closed%	p-value
Celso palmieri edward ellis 1999	-1.3±7.9 N = 62	1.7±14.7 N = 74	-	-	ns
Edward ellies iii 2000	-3.16±7.50 N = 35	-3.51±6.58 N = 31	-	-	ns
Wen guei yang 2002	6.14±4.19 N = 22	2.79±1.25 N = 14	-	-	0.062

mandibular function along with restoration of the preinjury occlusion. Open reduction of condylar fractures has the advantage of immediate and complete restoration of the anatomical relationships of the joint and rigid fixation allows for immediate and full function of the mandible.

Following condylar fracture of the mandible, patients adapt to the injury by compensation mechanism which is divided as follows Skeletal, Neuromuscular, Dental. Intervention by the surgeons either by open or closed reduction minimizes the dental compensation. It is noted that there is a decreased masseter activity on the fractured site transferring load to a non-fractured site. This results in neuromuscular adaptation which may also be a protective phenomenon. In case of an open reduction, there is minimum amount of neuromuscular adaptation. Usually a closed reduction results in an articulation which is inferior and anterior to the articular eminence which may limit the transitional movement. This can be avoided by open reduction and fixation. Minimum complications have been reported in the studies evaluating closed reduction in treatment of condylar fractures as pain and mouth opening were the only criteria which were evaluated. A reduction in the incidence of malocclusion and lateral deviation on opening, along with an improved protrusive and laterotrusive movements, were noted in patients treated with surgical therapy. Compared to closed reduction where skeletal and neuromuscular adaptation is seen, in open reduction only neuromuscular adaption will take place following treatment.

In 1983, Zide and Kent enumerated absolute and relative indications of open and closed treatment for condylar process fractures. However, application of absolute indications is limited in clinical practice. Traditionally condylar fracture was mostly treated by closed reduction. Newer surgical trends follow the open reduction and internal fixation approach. As in ORIF, the advantages like restoration of jaw anatomy, no significant ramal height shortening, decreased deviation, no need for MMF, increased mouth opening and better jaw movements and decreased malocclusal rates. On other hand closed reduction offers various advantages like no need for complex surgery, restoration of function, no need for longer hospital stays and economical.

The major disadvantage of ORIF are complicated process of surgery, post operative complications like transient facial nerve anaesthesia, scarring, ankylosis, arthritic changes in joint. The major disadvantage of closed reduction is reduced posterior mandibular ramal height, facial asymmetry, deviation, malocclusion.

The goal of this meta-analysis is to judge the surgical and functional outcome of ORIF and CR in terms of maximum interincisal distance, protrusion and excrusion movements. The meta-analysis could not assess the malocclusion, deviation, coronal and sagittal angulation due to incomplete data.

In terms of maximum interincisal distance in our meta-analysis we do not find any statistically significant difference between the surgical and the functional outcome of the treatment. According to Berner *et al*.[5], who performed a meta-analysis comparing the open and closed treatment of mandibular condyle fractures in which he too didn't find any difference concerning mouth opening. A meta-analysis conducted in 2014 by Yao *et al*.[6] concluded that Surgical treatment has significant advantages in improving the maximal mouth opening. In terms of protrusion and excrusion movement in our meta-analysis we do not find any statistically significant difference between the surgical and the functional outcome of the treatment. According to Berner *et al*.[7], who performed a meta-analysis comparing the open and closed treatment of mandibular condyle fractures in which the analysis showed that open treatment resulted in significant improvements for protrusion and excrusion movements. A meta-analysis conducted in 2014 by Yao *et al*.[6] concluded that Surgical treatment has no satistical significant difference in protrusion and excrusion movements as compared to closed reduction. (Konstantinovic and Dimitrijevic[7], Palmieri *et al*.[8], Takenoshita *et al*.[9] found little difference in mandibular motion (lateral excursive, protrusive, mouth opening) between patients treated for fractures of the condylar process by either closed or open methods.

Today, open treatment is generally accepted for dislocated fractures, and there is a widely accepted consensus for open treatment for displacement above 45°. Open treatment is also considered to be contraindicated for head fractures, because of the

high risk of avascular necrosis, which can lead to a loss of function and the screws can damage the disk and the glenoid fossa. However, Schneider *et al*.[10] showed better outcomes in condylar head fractures in patients after open reduction and internal fixation than in conservatively treated patients. Handschel *et al*.[11] concluded that the treatment of condylar head or intracapsular fractures remained controversial.

Some studies included unilateral and bilateral fractures, whereas other studies included only unilateral fractures. Schneider *et al*.[10], Gupta *et al*.[12] and Singh *et al*.[2] reported that treatment of bilateral fractures had better results with open treatment. The follow-up times varied among the studies. The follow-up time for retrospective studies ranged from a few months to years. The follow-up time for prospective studies was 6 months for Singh *et al*.[13], Schneider *et al*.[10] and Eckelt *et al*.[32] and up to 42 months for Danda et al.[14].

Ellis *et al*.[24] described better occlusal results after open treatment. Palmieri *et al*.[23] showed that patients undergoing open treatment had better condylar movement. This might be explained by the fact that the fracture heals in a misaligned position in the closed treatment group. Shortening of the ramus, with closed methods, can lead to asymmetric faces. Better functional results can be expected with open treatment, because the anatomical reduction reduces the need for extensive remodelling and neuromuscular adaption.

Even with advancement of instruments and skills, minimally invasive open reduction with lesser complication, there are still no rules or norms decided for treating condylar fracture. The factors, resulting difference in the outcome of treatment were presence of the MMF after open reduction, also the total time of immobilization after the reduction, longer time of immobilization may lead to ankylosis of joint. A bias, present as the subject suffering from different types of unilateral/bilateral condylar fracture (condylar head, condylar neck and sub condylar) are taken randomly in the studies. The dislocated condylar fracture or severely displaced fracture are mostly considered for the open reduction while on other hand in paediatric condylar fracture, closed reduction is preferred. Even though the newer studies trend towards the open reduction the advantages of functional outcome of closed reduction are not deniable.

CONCLUSION

There is no definite protocol fixed for treating the condylar fracture, there is no statistical data which favours the fracture treated by either surgical means i.e., Open Reduction Internal Fixation or by functional restoration i.e., Closed Reduction. So, it depends on various factors like age of patient, degree of displacement, type of anatomical region fractured, economic condition and mainly surgeon's experience and approach towards the type of treatment. The ultimate goal to restore the functional ability of the joint, least or no facial asymmetry, painless movements and occlusion with patient compliance.

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