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Original Article

Three-dimensional assessment of unilateral subcondylar fracture using computed tomography after open reduction

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ABSTRACT

Objective: The aim was to assess the accuracy of three-dimensional anatomical reductions achieved by open method of treatment in cases of displaced unilateral mandibular subcondylar fractures using preoperative (pre op) and postoperative (post op) computed tomography (CT) scans. **Materials and Methods:** In this prospective study, 10 patients with unilateral sub condylar fractures confirmed by an orthopantomogram were included. A pre op and post op CT after 1 week of surgical procedure was taken in axial, coronal and sagittal plane along with three-dimensional reconstruction. Standard anatomical parameters, which undergo changes due to fractures of the mandibular condyle were measured in pre and post op CT scans in three planes and statistically analysed for the accuracy of the reduction comparing the following variables: (a) Pre op fractured and nonfractured side (b) post op fractured and nonfractured side (c) pre op fractured and post op fractured side. $P < 0.05$ was considered as significant. **Results:** Three-dimensional anatomical reduction was possible in 9 out of 10 cases (90%). The statistical analysis of each parameter in three variables revealed ($P < 0.05$) that there was a gross change in the dimensions of the parameters obtained in pre op fractured and nonfractured side. When these parameters were assessed in post op CT for the three variables there was no statistical difference between the post op fractured side and non fractured side. The same parameters were analysed for the three variables in pre op fractured and post op fractured side and found significant statistical difference suggesting a considerable change in the dimensions of the fractured side post operatively. **Conclusion:** The statistical and clinical results in our study emphasised that it is possible to fix the condyle in three-dimensional anatomical positions with open method of treatment and avoid post op degenerative joint changes. CT is the ideal imaging tool and should be used on a regular basis for cases of condylar fractures.

KEY WORDS

Computed tomography; imaging; open reduction; three-dimensional; unilateral condyle fractures

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INTRODUCTION

It is a well-known fact that controversy still exists as to whether the condyle needs an open treatment or closed treatment to regain its maximum functionality. Closed reduction is often associated with reduced mouth opening, decreased patient compliance, and potential

for ankylosis, internal derangement of joint and delayed restoration of function.[1-4] Owing to these factors surgeons today prefer open reduction and internal fixation of displaced condylar fractures in adults, as this permits good anatomic repositioning and immediate restoration of function.[5,6]

Advocates of closed reduction feel that condyle can be fixed in unphysiological position with open reduction leading to severe postoperative (post op) degenerative joint changes and injury to the facial nerve.[7-9]

In spite of these drawbacks, open reduction and internal fixation of condylar fractures, if performed as per standardised surgical procedures (access through a retromandibular/preauricular approach and fixation of condyle respecting champy's principles of osteosynthesis) have been reported to give good, predictable and reproducible results.[10,11]

With recent advances in the imaging techniques with computed tomography (CT) and availability of three-dimensional visualisation of the fractured condyle, there is a tremendous improvement in the understanding of the nature, degree of displacement, dislocation and other minute details of these fractures. These findings were not possible with conventional radiography, which provided the images in two-dimensions.

MATERIALS AND METHODS

In this prospective study, 10 patients attending the department of oral and maxillofacial surgery with unilateral subcondylar fracture confirmed with panoramic radiograph were included after ethical committee approval was obtained from institutional review board and structured informed consent was taken after explaining the possible hazards of radiation with CT. The mean age of the patient was 22.5 with an age range of 15-30 years. Patients with Unilateral subcondylar fracture of the mandible with displacement, deviation and dislocation of the condyle, age below 60 years and young patients with a full set of permanent teeth were included in this study. Bilateral condylar fractures, patients not willing for open reduction and opting for conservative management and medically compromised patients were excluded from the study.

Surgical procedure

All the patients underwent a routine surgical workup, which included surgical profile, chest X-ray, electrocardiograph and pre anaesthetic evaluation. All the patients were treated by the same surgeon, underwent open reduction and rigid fixation using a retromandibular transparotid approach and fractures fixed with two holed 2 mm stainless steel double miniplate osteosynthesis.

Retro mandibular approach

A 3-4 cm incision was placed inferior to pinna of the ear and 1 cm posterior to the angle of the mandible [Figure 1]. The incision was placed through the skin and subcutaneous tissue and dissection carried out until the subplatysmal layer was reached. Blunt dissection was done in retromandibular region, through the parotid gland and fibres of the masseter were identified and incised. The condyle and posterior border of the ramus were exposed by subperiosteal dissection in a postero lateral direction. An autys retractor was placed in the posterior border. A firm downward pressure was applied intraorally to the ipsilateral third molar to depress the mandible, thereby facilitating reduction of the displaced condylar fragment. Fixation was achieved with a 2 mm, two holed stainless steel osteosynthesis system [Figure 2]. Watertight closure of the masseter and parotid capsule was achieved with resorbable sutures, and the skin was approximated with nonresorbable sutures.

Patients were evaluated by CT imaging pre operatively and 1 week post operatively. A Siemens six emotions scanner was used for the CT examination with the following scan parameters: Slice thickness 2 mm; scan time 20 s; 70 kV; and 250 mAs. Transverse, coronal and sagittal projections were made to allow both condylar processes to be observed. The measurements were done

Figure 1: Exposure of fracture site through a retromandibular approach

on standard anatomical landmarks as suggested by Choi *et al*.[12] In the transverse plane [Figure 3a-c] a reference paramedian line was drawn to pass through the nasal septum and the centre of the occipital foramen. Another transverse line was drawn tangentially to the posterior border of the condyle. The following parameters were then measured: Condylar distance (distance between the condyle and the paramedian reference line); condylar length (CL: Longest diameter of the condyle); and condylar angulation (CA: Angulation between the long axis of the condyle and the transverse posterior line). In the coronal plane [Figure 4a-c] the parameter measured was Proximal Distal stump angulation (PDSA). In the sagittal plane [Figure 5a-c] the following parameters were measured: The superior joint space (S1: Distance between the roof of the temporal fossa and the top of the condylar head); the closest anterior joint space (S2); and the closest posterior joint space (S3) and ramus height (RH): Distance from the posterior most point on the angle and superior most position on the condylar head. The data obtained were tabulated as preoperative (pre op) master chart and post op master chart for all the parameters. All measurements were done directly in the computer using Syngo Samiro, Siemens emotions six software. Measurements were done by four different persons and mean of the four values were taken. All parameters measured on the pre op CT and post op CT were statistically compared for three variables:

a. Pre op fracture and nonfracture side.
b. Post op fracture and nonfracture side.
c. Pre op fracture and post op fracture side.

The results obtained for each parameter were statistically analysed for the three variables using a Wilcoxson's signed rank test for paired samples.

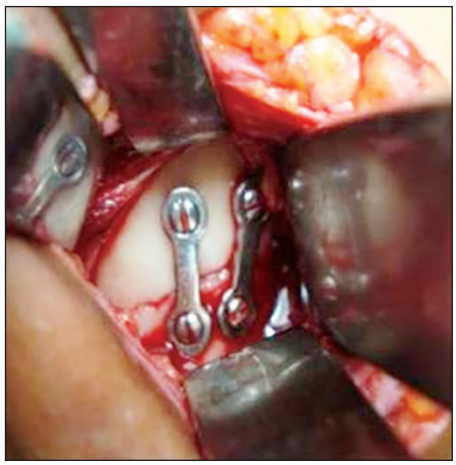

Figure 2: Fixation of fracture with 2 mm double miniplate

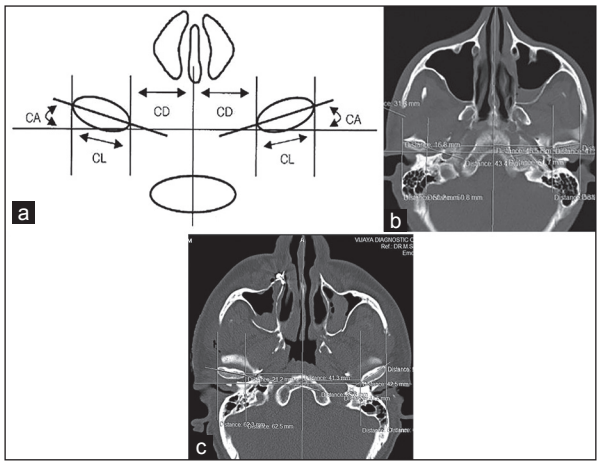

Figure 3: (a) Line diagram showing measurement made in axial plane, (b) preoperative computed tomography (CT) showing measurements in axial plane, (c) postoperative CT measurements in axial plane

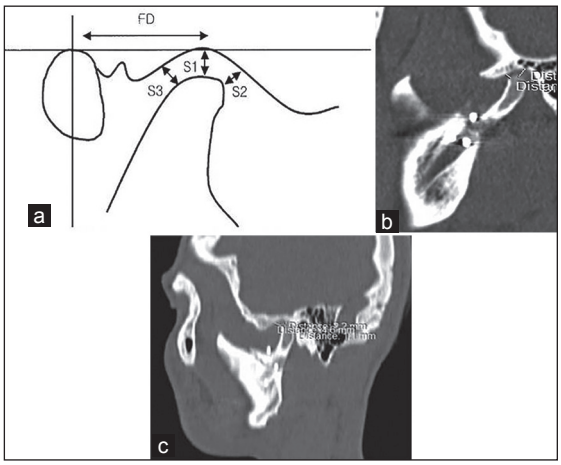

Figure 4: (a) Line diagram showing measurement in sagittal plane, (b) preoperative computed tomography showing measurement in sagittal plane (c) postoperative measurements in sagittal plane

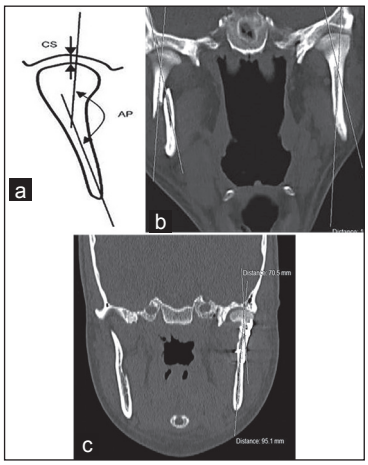

Figure 5: (a) Line diagram showing measurement in coronal plane, (b) computed tomography (CT) slice showing measurement in coronal plane, (c) postoperative CT measurement in coronal plane

RESULTS

The statistical analysis of each parameter in three variables revealed that there was a gross change in the dimensions of the parameters obtained in pre op non fractured and fractured side [Table 1].

When these parameters were assessed in post op CT for the three variables there was no statistical difference between the post op fractured side and nonfractured side [Table 2]. This result indicates that condyle can be fixed to its pre fracture conformal position by open method. Two cases had a medial displacement of almost 90° which were reduced satisfactorily.

The same parameters were statistically analysed for the three variables in pre op fractured and post op fractured side and found considerable change in the dimensions of the fractured side post operatively suggesting a good achievement of anatomic reduction [Table 3].

DISCUSSION

Whether the fractured condyle needs an open treatment or closed treatment to regain its maximum functionality still remains hotly debated. Advocates of closed reduction emphasise that even if condyle is fixed by open method one cannot assure reduction close to its pre fracture position and avoid the post op degenerative joint changes. Moreover the complex anatomy of the temporomandibular joint (TMJ) and potential damage to the facial nerve has always added to the problems of access to these joints. With the improved surgical approaches like retromandibular approach for subcondyle

Table 1: Statistical analysis of preoperative fracture and nonfracture side

Measurement	Preoperative fracture side	Preoperative nonfracture side	*P* value	Inference
CD	34.37±3.42 mm	39.4±2.98 mm	0.005	Significant
CL	19.77±1.36 mm	19.33±1.33 mm	0.92	Insignificant
CA	38.20°±8.51°	24.90°±8.46°	0.005	Significant
PDSA	138.90°±36.38°	165°±9.95°	0.036	Significant
S1	5.84±3.85	2.62±0.037 mm	0.037	Significant
S2	4.88±4.09 mm	2.20±0.68 mm	0.012	Significant
S3	6.50±5.07 mm	1.74±0.58 mm	0.005	Significant
RH	57.06±10.78 mm	65.74±5.68 mm	0.007	Significant

CD: condylar distance; CL: Condylar length; CA: Condylar angulation; RH: Ramus height; S1: distance between the roof of the temporal fossa and the top of the condylar head; S2: The closest anterior joint space; S3: The closest posterior joint space; PDSA: Proximal and distal stump angulation

Table 2: Statistical analysis of post op fracture and nonfracture side

Measurement	Postoperative fracture side	Postoperative nonfracture side	*P* value	Inference
CD	40.15±3.10 mm	39.40±2.98 mm	0.285	Insignificant
CL	19.20±1.50 mm	19.33±1.33 mm	0.92	Insignificant
CA	26.90°±7.87°	24.90°±8.46°	0.052	Insignificant
PDSA	167.40°±36.38°	165.60°±9.95°	0.511	Insignificant
S1	2.58±1.44 mm	2.62±0.86 mm	0.72	Insignificant
S2	2.15±0.86 mm	2.20±0.68 mm	0.402	Insignificant
S3	2.42±1.20 mm	1.74±0.58 mm	0.184	Insignificant
RH	64.05±7.16 mm	65.75±5.58 mm	0.128	Insignificant

CD: condylar distance; CL: Condylar length; CA: Condylar angulation; RH: Ramus height; S1: distance between the roof of the temporal fossa and the top of the condylar head; S2: The closest anterior joint space; S3: The closest posterior joint space; PDSA: Proximal and distal stump angulation

Table 3: Statistical analysis of preoperative fracture and postoperative fracture side

Measurement	Preoperative fracture side	Postoperative nonfracture side	*P* value	Inference
CD	34.37±3.42 mm	40.15±3.10 mm	0.005	Significant
CL	19.77±1.36 mm	19.20±1.50 mm	0.44	Insignificant
CA	38.20º±8.51º	26.90º±7.87º	0.005	Significant
PDSA	138.90°±36.38º	167.40°±6.04º	0.008	Significant
S1	5.85±3.85 mm	2.58±1.44 mm	0.040	Significant
S2	4.88±4.09 mm	2.15±0.86 mm	0.028	Significant
S3	6.50±5.07 mm	2.24±1.20 mm	0.022	Significant
RH	57.06±10.78 mm	64.05±7.16 mm	0.009	Significant

CD: condylar distance; CL: Condylar length; CA: Condylar angulation; RH: Ramus height; S1: distance between the roof of the temporal fossa and the top of the condylar head; S2: The closest anterior joint space; S3: The closest posterior joint space; PDSA: Proximal and distal stump angulation

and parotidectomy approach[12] for high condyle it is possible to minimise these complications and maximize efficacy of reduction and fixation.

Conventional radiographs are generally imprecise in the condylar region due to complicated anatomic bone structure in the area, lack of sharpness and image distortion. These limitations have been largely overcome by CT which enables the assessment of the joint morphology and condylar position in the mandibular fossa three-dimensionally along with three-dimensional reconstruction of the condyle, which can delineate the minute physiological, mechanical and biological changes in the TMJ in the absence of superimposed interfering structure.

There are many long-term studies conducted and published comparing the merits and demerits of closed and open reduction.[3,4] However, very few studies have been conducted to show the accuracy achieved by the open method.[12]

This study was basically aimed to assess the accuracy of the open method of treatment with the help of CT and it found very little difference in the anatomical position of the condyle in pre op fracture and post op fracture side.

In cases of condylar fractures the concern is that intraoperative repositioning of fracture borders along the condylar neck will not guarantee a correct three-dimensional physiologic positioning of the condyle in the fossa. Even an intraoperatively correct adjustment of the fracture borders along the buccal aspect will often result in a slight inclination that leads to a significant medial angulation of the condyle.[12] The ability to perform anatomic reductions is based largely on the access and visibility provided by the chosen surgical approach which in this study is retromandibular approach.[10,11]

Coronal view of CT is the most suitable method of diagnosing high condylar process fractures and other facial fractures as it allows visualization of anatomical structures — e.g., cortical bone loss, sclerosis, and changes in joint morphology and condyle position in the mandibular fossa — free of superimposition, providing the viewer with three-dimensional information if sequential images are reconstructed.[13] Coronal slices provides better diagnostic images than axial or sagittal plane because first, coronal plane is perpendicular to both the sagittal and horizontal struts and less slices are required for evaluation of face so less radiation exposure.

The Findings of this study are similar to that shown by Choi *et al*.[12] in which he did a study in operated cases of condylar fractures after 3 months and compared the fractured side with nonfractured side and found no major difference between the two sides and minimal post op joint changes.

Computed tomography images in sagittal plane helps to evaluate the spatial localisation of the fragments[14,15] and may contribute to determine the choice of better treatment of condylar fractures. In fact, the three-dimensional reconstruction of CT images allows a more accurate and complete assessment of the articular space. The reconstruction method provides a complete anatomical picture and directly shows static and functional interactions. It also helps to assess most important parameters like loss of the vertical RH that is a predictor for the possible malocclusion, asymmetry, decreased posterior facial height, occlusal cant and neoarthrosis with the articular eminence.[16]

A greater fragment dislocation is the result of a stronger traumatic impact leading to capsular rupture and scar formation. It is thought that mobility of TMJ does not depend exclusively from the osseous traumatic alteration but also from muscular and ligament damage with scar formation.[17,18] The open reduction can significantly reduce the complication associated with the closed reduction like shorter posterior facial height, RH, occlusal cant and post op joint changes.[5]

All the parameters were statistically significant between pre op fracture side and nonfracture side in space 1, space 2, and space 3. After open reduction and internal fixation it was insignificant in all the three spaces. These results revealed that even minute changes in the joint spaces were corrected by open method of treatment and for assessment of this small space CT is the best tool. If relationship of the condylar head and articular fossa is not maintained it may lead to severe stretching of the articular ligaments and muscles and may have long-term complications of pain, occlusal instability and degenerative joint changes. With open reduction and CT scan it was possible to achieve almost the same static and functional position to that of the contralateral side.

Axial view of CT shows a fractured condylar head, amount of displacement of the fractured segments, deviation, displacement, dislocation and dicapitular fractures of condylar head. It also gives the clear picture of continuity of the fractured condylar head with distal part of mandibular segment and also medio lateral rotation of the fractured condylar stump.

Statistical analysis for CL was insignificant in all the three variables. For CL to increase in length there needs to be direct fracture of the condylar head or the so-called dicapitular fractures.[19,20] Pertaining to this study no cases were associated with any fracture of the condylar head and no major changes were seen. Even if these fractures were present in any of the cases it is unlikely that these can be picked up by the conventional radiographs. These fractures can only be diagnosed with the help of the CT scans with three-dimensional reconstruction.[21]

Condylar distance is a valuable measurement method as most of the subcondylar fractures tend to displace the head of the condyle medially rather than laterally, anteriorly or posteriorly due to the pull of the lateral pterygoid muscles medially. Two cases in this study had severe rotation of the proximal stump, which were aligned in anatomically stable position. The lateral pterygoid was left attached to the proximal segment, but has to be detached from the capsule to achieve access to the displaced condylar segment and prevent resorption of the displaced segment. These findings are in accordance with Pereira *et al*.[22] and Suuronen *et al*.[23] who showed with the help of CT that if these fractures are not treated the relationship of the condyle and fossa doesn't improve, instead the reestablishment of occlusion and function appear to occur not as a result of anatomic restitution of condylar height, but as a result of adaptation of the masticatory muscles.[24]

The CA is the most frequently evaluated parameter in which changes on the condylar twist formed by the angle between a line from posterior condylar base and condylar head major axis in the axial projection is seen. This parameter allows a quantitative assessment of the degree of mobility of a fractured condyle in the follow-up after open reduction.[25] Statistical analysis of the CA lead to the conclusion that with open reduction it is possible to fix the condyle in its pre op conformal state and can be assessed successfully with the help of the CT without any interferences and with maximum accuracy. These findings were in line with those shown by Choi *et al*.[12]

Usually rigid internal fixation produces accurate reduction and allows immediate function.[26] Advantages of rigid internal fixation are accurate fixation, rigidity of bone fragments, primary healing of bone and reduced periods of intermaxillary fixation and allow immediate function. Post op mandibular function was significantly greater in patients treated with miniplates rigid fixation method over other methods. Disadvantages include condylar resorption and osteoarthrosis in cases treated by rigid fixation than in cases using a transosseous wiring.

As no surgical procedures are without complications, along with minor complications of post op oedema, trismus, mild facial nerve weakness in 1 case (10%) there were no major complication associated with any of the procedures except in one case where there was over riding of the proximal and distal stump post operatively, which lead to difference in RH as against the height of the contralateral side post operatively. As occlusion was stable and displacement was minimal no further operative procedure was done. Patient was kept on intermaxillary fixation for a period of 21 days.

The different parameters analysed in this study (superior joint space, closest anterior joint space, closest posterior joint space, and fossa distance) proved to be adequate, having a low inter-observer variation and the greatest concordance.[8] Similar study was done in 10 patients with unilateral condylar fractures in which only post op CT scans were taken where as in the present study both pre op and post op CT scans were taken and analysed.[12]

We were able to achieve good anatomical reduction and function post operatively as shown in Figure 6a and b. Based on this clinical, radiological and statistical analysis it can be said that with open reduction and internal fixation it is possible to fix the condyle in its pre fracture position and computer assisted scans are the ideal imaging tools available at present for evaluation.

Figure 6: (a) Preoperative mouth opening, (b) postoperative mouth opening

CONCLUSION

This study through its radiological analysis with a pre op and post op CT and statistical analysis of measurements of the anatomical parameters favours the fact that open reduction and internal fixation is a viable choice for three-dimensional anatomical reduction and fixation of the fractured condyle with immediate restoration of form, function and appearance, minimal disability and would lead to minimal post op degenerative joint changes.

There are very few studies in literature which report the immediate assessment of the reduced condyle by open method, so that any inadequacies pertaining to the positioning of the condyle can be addressed rather than waiting for the post op degenerative joint changes to take place. Studies with longer period of follow-up and larger samples can give better understanding of post traumatic changes associated with mandibular condyle.

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