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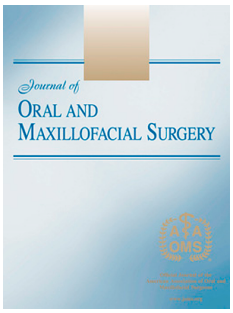

Are facial asymmetry and condylar displacement associated with ramus height and treatment outcomes in unilateral condylar fracture when managed by closed method?

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Are facial asymmetry and condylar displacement associated with ramus height and treatment outcomes in unilateral condylar fracture when managed by closed method

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Facial symmetry

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Are facial asymmetry and condylar displacement associated with ramus height and treatment outcomes in unilateral condylar fracture when managed by closed method ?

Purpose: This study measures the mandibular ramal height in patients with unilateral condylar fracture managed by closed method using elastic intermaxillary fixation (IMF). It's co-relation with facial asymmetry and condylar displacement were assessed. This will determine whether the treatment outcome is in favour of closed or open method.

Methodology: A prospective cohort study was performed. Subjects included patients with unilateral condylar fracture who reported to SDM Craniofacial & Research Centre, Dharwad, India. All subjects in the study were managed by closed method (non-surgically, using arch bars and elastic IMF). Standardised orthopantomogram radiographs were used to assess ramal height and condylar displacement in sagittal plane. PA mandible and reverse Towne's radiographs were used to assess facial asymmetry and condylar displacement in coronal plane during pre-treatment, immediate post-treatment, 3rd, 6th and 12th month follow-up. Data was subjected to statistical analysis by using ANOVA test and Karl Pearson's correlation coefficient method.

Results: 25 patients with unilateral condylar fracture managed by closed treatment had significant reduction in ramal height on the affected side by 1.15mm ($p=0.0001$) at 12th month follow-up. Change in facial asymmetry was reported as 1.05mm ($p=0.0016$) at 12th month follow-up. It was noted that its correlation with ramal height was insignificant ($p=0.07$). Only significant correlation noted between facial asymmetry and condylar displacement was in coronal plane at 12th month follow-up ($p=0.04$).

Conclusion: A weak positive co-relation was noted among the assessed values during the 12th month follow-up radiographs. Facial symmetry is not greatly affected when the ramal height at the time of injury on the fractured side is reduced by 3.25±0.6mm.

Introduction:

The anatomic position of the mandible in the skull is more prominent than other aspects of the facial anatomy. This makes it more vulnerable and exposed, leading to a higher incidence of fractures among all head and neck injuries. Incidence of mandibular fractures has varied with time. Current range of mandibular fractures is between 17.5-52% [1,2] . Traditionally, mandibular fractures exceed mid-facial fractures by a ratio of 2:1[3]. Among the mandibular fractures, fracture of the condyle can significantly alter occlusion, mandibular range of motion and muscle activity. The consequences are pain, restricted mouth opening, deviation on opening of mouth and facial asymmetry.

Treatment of fractures of the condyle depends on many factors. Prime factors include clinical and radiological evidence for the presence of the fracture, type and extent of fracture, degree of displacement or dislocation, malocclusion , posterior occlusal support, clinical experience of the surgeon and willingness of the patient to undergo surgery. Other factors include, patient's age, systemic conditions, possibility of occlusal restoration by intermaxillary fixation (IMF), and existence of foreign materials[1,4,5,6] . Condylar fractures in children can have devastating effects, if managed poorly. TMJ ankylosis is the most grievous consequence in such situations. This can further lead to growth disturbances causing deformities and severe obstructive sleep apnoea. Condylar fractures in children are usually managed non-surgically with or without the use of functional IMF with guiding elastics. The key is short-term immobiliization. Irrespective of the type of management, treatment goals remain common, viz; achieve pain-free mouth opening, good movement of the jaw in all excursions, achieve pre-injury occlusion of the teeth, stable temporomandibular joint (TMJ) and facial and jaw symmetry.

Facial asymmetry has been considered as one of the important determinants in management of condylar fractures. Discontinuity of the ramus-condyle unit, unless undisplaced can cause a degree of facial asymmetry and deviation in mouth opening. Less asymmetry has been observed in patients treated open reduction and internal fixation [7,8]. Surgical management by open reduction and internal fixation restablishes the condylar support thus, contributes to the facial height.

A functionally stable occlusion can be achieved with appropriate functional elastic IMF. Bio-mechanical basis for this treatment is provided by Ellis and Throckmorton [9]. But, parameters such as reduction in ramal height and facial asymmetry are not corrected leading to a progressive change in facial morphology [10]. Ramal height and

facial asymmetry are also important determinants of a successful treatment irrespective of modality. The purpose of this study was to assess changes in ramal height in unilateral condylar fractures treated by closed method and their co-relation with facial symmetry, condylar displacement in both coronal and sagittal plane during a successive follow-up period of 1 year. We aimed at estimating the amount of pre-treatment ramal height reduction on fractured side in unilateral condylar fractures. Specifically, with this co-relation among the variable parameters, we wanted to determine whether the treatment outcome would be in favour of closed or open method.

MATERIALS AND METHODS:

A prospective cohort study was carried out in patients with unilateral condylar fracture who reported SDM Craniofacial & Research Centre , Dharwad between 2014 – 2016. Approval for this study was obtained from the Institutional Review Board and Ethical committee (IRB. No. 2014/P/OS /25). Informed consent was obtained from all patients who were enrolled in this study. Patients with unilateral condylar fracture were included in the study based on the following criteria.

Inclusion criteria:

• Unilateral condylar fracture which may or may not be associated with other facial fractures.

• Patient with unilateral condylar fractures who refused surgical treatment.

- Molar dentition

• Periodontally stable teeth to facilitate:

  - fixation of conventional Erich arch bars
  - Achieve IMF
  - Allow assessment of occlusal relationships.

• Patients with no previous history of TMJ dysfunctions

• Patient's consent to participate in the study

Exclusion criteria:

• Patients with bilateral condylar fracture.

•Patients with the history of epilepsy, psychosis, schizophrenia, pulmonary disorders like chronic obstructive pulmonary disease and gastrointestinal disorders like gastro - oesophageal reflux disorders.

Management for all patients consisted of IMF using conventional Erich arch bars and guiding elastics (2 – 3weeks).

Radiographs used were standard orthopantomogram radiographs, PA-view of mandible and reverse Towne's projection. They were taken pre-treatment, immediate post -treatment and during the follow-up reviews on 3rd, 6th and 12th month. Radiographs were captured in the Department of Radiology and standardized with cephalostat on a Pax-400C (Vatech, Korean Co.). The radiographs were traced by the principal investigator and cross-analysed by another investigator. Ramus height, facial symmetry, condylar displacement were measured as per recommendations by Ellis et al.[11,12] (fig.1-3).

1. Ramus height: Referred to a perpendicular line drawn on a orthopantomogram from a point located at the most superior aspect of the condyle and the bigonial line .

2. Facial Symmetry: Referred to horizontal cranial reference line drawn on a PA view of mandible tangentially to supra-orbital rim. Alternatively, a line could also be drawn through the intersection of the greater wing of sphenoid bone within the orbit, in situations where the previous reference plane was not clear. Perpendicular distances between this line and gonion was measured bilaterally. Measure of vertical facial symmetry was defined as the difference between the posterior facial height on the fractured and non-fractured sites.

3. Condylar Process Displacement:

It was measured in two planes i.e.

i. Coronal plane

ii. Sagittal plane

•Coronal plane: was measured on the Towne's projection view by drawing a line between the medial and lateral poles of the condyle. Another line was drawn tangentially to or through the ramus. The inner angle formed by the intersection of the two lines was calculated. The difference between the angle on the non-fractured and the fractured side was used as a measure of coronal displacement of condylar process.

•Sagittal plane: It was measured on panoramic view by drawing a line tangentially to the posterior border of the condylar process on each side and reference line was drawn through both the gonial angles. Sagittal displacement of condylar process both on the fractured and non-fractured side was defined as the difference between intersection of the tangent to the condylar process and the reference line was

Correlation of ramal height change with facial symmetry and condylar displacement in both coronal and sagittal plane was evaluated through radiographs at various intervals. Then data was compiled and subjected for statistical analysis by using ANOVA test (

SPSS V20), Karl Pearson's correlation coefficient method. Statistical significance was defined at $p<.05$ for all statistical tests.

Measurement variability:

Although, investigator performed tracing and digitization of standard radiographs 3 times , the intraexaminer linear and angular measurement variabilities recorded were ±0.45 mm and ±1.2°. Interexaminer measurement variability estimated ±0.13° (angular) and ±0.3 mm (linear) .

RESULTS:

A total of 25 patients (22 males and 3 females) with unilateral mandibular condylar fracture were included in this study . All 25 patients were treated with closed method. Out of 25 patients, 21 patients were associated with other facial fractures i.e. 8 patients had right parasymphysis and left condylar fracture of mandible, 3 patients had right body and left condylar fracture of mandible, 10 patients had left parasymphysis and right condylar fracture of mandible and the remaining 4 patients had isolated unilateral condylar process fracture. Based on the side of fracture, 15 patients had left and 10 patients had a right side condylar fracture. Based on the levels of fracture (Lindahl's classification)[13], 3 patients had condylar head fracture, 4 had high condylar neck fracture and the remaining 18 patients presented with sub condylar fractures (Table 1).

Ramus height: The mean pre-treatment ramus height on fractured side was 67.1 ± 7.61mm (P= 0.1680). There was no significant change in mean immediate post-treatment ramus height on fractured side (p=0.1680). Reduction in ramus height was examined on 3rd, 6th and 12th month of follow up which showed a mean value of 0.70, 1.15, and 1.15mm, respectively, with p values being 0.0093, and 0.0001, 0.0001, respectively, which showed a remarkable change.

Facial symmetry: The mean pre-treatment and immediate post-treatment facial symmetry was similar on fractured side, value being 95.38 ± 4.53 mm (p=0.2881). On follow up at 3rd, 6th and 12th month a change of 0.80, 1.05, and 1.05mm respectively was noted, respectively. The change in facial symmetry was statistically notable during 6th and 12th month of follow up with p value of 0.0016.

Condylar displacement in coronal and sagittal planes: The mean pre-treatment and immediate post-treatment of the coronal plane on the fractured side was 87.65˚±8.82˚ and the mean pre-treatment and immediate post -treatment on the sagittal plane were 82.23˚±9.82˚ and 81.28˚±9.21˚, respectively. During the 3rd, 6th and 12th month follow-up, a continuous change was seen in the condylar displacement in coronal plane by 0.58˚, 0.63˚ and 0.63˚, respectively. A p value of 0.367, 0.3283, and 0.3283, respectively, showed an insignificant change. Whereas, in the sagittal plane the condylar displacement during the 3rd, 6th and 12th month was seen to be 0.30˚, 0.95˚, and 0.95˚, respectively. But statistically, the p values of 0.1088 and 0.1459 were insignificant (Table-2).

Correlation between Ramus height, Facial symmetry, Condylar displacement in coronal plane and Sagittal plane in fracture group:

At 1.15 mm reduction of ramus height on fractured side during 12th month follow-up, there was a change in facial symmetry by 1 mm. There was a weak positive correlation between ramus height and facial symmetry which was statistically insignificant. Reduction in ramus height by 1.15 mm on fractured side lead to a change in the condylar displacement in coronal and sagittal plane by 0.63˚ and 1.15˚, respectively. Hence, there was a weak positive correlation between ramus height and condylar displacement in both coronal and sagittal plane. However, this is not of statistical significance as the p values are 0.08 and 0.64, respectively.

Moderate positive correlation was noted between facial symmetry and condylar displacement in coronal plane on fractured site. This was statistically significant as the p value was 0.04 where as weak positive correlation was noted between facial symmetry and condylar displacement in sagittal plane.

Very weak positive correlation was noted between condylar displacement in coronal plane and sagittal plane (fig.4)

DISCUSSION:

Fracture of the mandibular condyle can significantly alter occlusion, range of motion and muscle activity resulting in consequences such as pain, restricted mouth opening, deviation on mouth opening and facial asymmetry. Treatment of condylar fractures aims at restoring normal function of the TMJ and re-establishing the pre-existing

physiological occlusion. Treatment of condylar fractures has generated more controversy than any other fracture in the facial skeleton. Some authors advocate conservative management due to disadvantages of surgery viz; facial nerve paralysis and surgical scar. On the contrary, proponents of open reduction internal fixation vouch for its benefits viz ; anatomical reduction and fixation, early return to function and maximum restoration of the mandibular range of motion[14,15] . Condylar fractures, unless undisplaced can cause a certain degree of facial asymmetry and deviation in mouth opening. Restoration of symmetry and prevention of deviation is possible only by open reduction and internal fixation as compared to non-surgical methods[12].

This radiographic study was done to assess the alterations in mandibular ramal height in patients with unilateral condylar fractures treated non-surgically using functional elastic IMF. Also, the changes in facial symmetry, condylar displacement in both coronal and sagittal plane during 12-month follow-up were assessed. We also aimed to evaluate the correlation between the assessed values, which may help in determining treatment modalities in future.

A total of 25 patients were included in this study out of which 22 were males with a mean age of 28.9 years and 3 were females with mean age of 33.6 years. Out of the 25 patients, 21 patients (84%) were associated with other facial fractures, while 4 patients (16%) had isolated unilateral condylar fracture. Based on the side of fracture, 15patients (60%) had left side condylar fracture and 10 patients (40%) had right condylar fracture. Again, based on the levels of fracture in the condyle, 3 patients (12%) had condylar head fracture, 4 patients (16%) had high condylar neck fracture and the remaining 18 patients (72%) presented with sub-condylar fracture.

The consensus with regards to sex ratio varies between 1.6:1 and 5.3:1 [1,16,17,18] .Our results are in accordance with this incidence viz ; 7.3:1 . Based on the anatomical region, there is a variation between incidences in the subcondylar region [17,19] and condylar neck region [20]. In our study the incidence of sub-condylar fracture was 72% which was higher than condylar neck and condylar head fracture.

A remarkable finding in our study was the loss of ramus vertical dimension (ramal height) in almost all patients (which also included undisplaced or minimally displaced condylar fractures). Significant loss of ramal height was present on the 3rd month of follow-up, indicating that the process responsible for the loss occurred relatively rapidly. There was a significant shortening of the ramal height that occurred from the 3rd month to the 12th month. This signified that the process of shortening continued for

at least 12 months. This has also been corroborated by Ellis and Throckmorton where they followed patients for a duration of 6 months [12]. Factors proposed by them are loss of the skeletal support between the mandibular angle and the joint, pull of elevator group of muscles and scar-contraction within inter-fragmentary gap [12]

Ellis in his study, noted similar features where ramus of the fractured side was 2mm shorter than the non-fractured side in patients treated non-surgically. There was a difference of 3 and 4.4mm after 6 weeks and 6 months, respectively[12]. Results of our study showed a reduction of 1.15 mm which was found to be notably similar and consistent with the above study.

A similar study was conducted in which facial symmetry was assessed in two treatment groups at various intervals. In patients treated by the closed method, shortening of the face on the side of fracture was noted in contrast to patients treated surgically. In the closed-method group , patients had almost 3 mm of shortening of facial height on the fractured side at the end of 6-weeks which increased to 4mm of shortening after 6 months. Upto 5 mm of shortening was noted at the end of 3 years. Contrary to this, patients treated surgically had less than 0.5 mm difference in facial height all intervals [12]. Findings of this study correlated with our study.

Zhang and Obeid performed a study comparing open reduction and internal fixation with closed treatment of unilateral condylar fractures in rabbits. Those treated by the closed method showed loss of ramus height, whereas those treated by open reduction and internal fixation with a miniplate showed no asymmetries [21].

To determine the facial changes after condylectomy, based upon alteration in biomechanics or loss of the condyle, Sorensen and Laskin made a comparison between the changes in adult monkeys after unilateral condylectomy and after surgical reduction of ramus height without removal of the condyle.[22] The latter procedure involved excision of a segment of bone in the sub-condylar region followed by osteosynthesis between the condylar process and the ramus, effectively shortening the ramus. The results showed posterior facial shortening on the operated side in both groups. As the skeletal changes in both groups were similar, it was likely that loss of posterior vertical ramus dimension was the reason for facial asymmetry. With loss of posterior ramus height, muscle forces were transferred to the posterior teeth, which acted as a new fulcrum. It appeared as though the teeth were not able to resist these continuous forces and were displaced apically. This probably accounted for the decreased maxillary and mandibular body height in the posterior area on the operated

side. The apical displacement of teeth allowed the mandible to move superiorly on the operated side while maintaining the occlusion.[22]

Resultant deformities are also related to growth. When a condylar fracture occurs earlier in life, resultant skeletal changes are greater. Development of asymmetries is linked to growth interference due to a damaged condylar cartilage or altered function. Asymmetry after condyle fractures is not uncommon. It has been shown to occur in approximately 25% of those individuals who had condyle fractures during the growing years [23].

With the outcome of 1.15 mm as the reduction of ramus height on fractured side, it can be concluded that there is a change in facial symmetry by 1 mm after 12 months of treatment. This correlation between ramus height and facial symmetry is positive but weak. Loss of posterior vertical dimension frequently accompanies closed treatment of condyle fractures, and the mandibular plane in such patients becomes more steep. This helps facilitate a new articulation by bringing the condylar stump closer to the cranial base. The more displaced the fractures, the more loss of vertical dimension seems to occur. However, once a new articulation is established, the posterior vertical dimension stabilizes.

Sudeesh et al. noted that the change in the degree of coronal displacement of the condyle at 12 months postoperatively from its position at pre-treatment is insignificant [24]. The results of this study were consistent with our study.

Greater coronal displacement of the condyle due to trauma for patients treated with closed treatment is associated with greater restriction in incisor as well as condylar movement [25]. The condyle makes attempts to attach itself to the abutting bone from which it fractured. During this period where the bone and soft tissues are healing, every attempt should be made to gain and maintain a wide range of jaw and circumarticular movement about a new articulation [26].

Ellis et al. noted that a mean change in the sagittal position of the condylar process was statistically insignificant while comparing immediate post-injury to immediately after placement of arch bars. Although, some did displace more anteriorly and others more posteriorly. Similarly, on comparing immediately after placement of arch bars to after 6 weeks, there was a great variability seen in position of the condylar process, but the overall change was statistically insignificant [11]. The results of this study were similar to our findings.

Correlation between ramus height, facial symmetry, condylar displacement in coronal plane and condylar displacement in Sagittal plane in fracture group:

With 1.15 mm reduction of ramus height on fractured side during 6^{th} and 12^{th} month follow-up, there was a change in facial symmetry by 1 mm. This ratio presented weak positive correlation between the two entities making the relation statistically insignificant. Moderately positive correlation between facial symmetry and condylar displacement in coronal plane on fractured site was noted with P value -0.04 where as weak positive correlation was noted between facial symmetry and condylar displacement in sagittal plane. Very weak positive correlation was also noted between condylar displacement in coronal plane and sagittal plane With the interception of weak positive co-relation among the assessed values during 12 month follow-up through radiographs, investigators hypothesise that unilateral condylar fracture with pretreatment reduction in ramal height by 3.25±0.6mm, on fractured side can be managed by a closed method.

Though, radiographs were standardised, traced and digitized thrice by the same investigator, linear measurement and angular measurement errors did occurred. This is another weakness of our study.

Conclusion:

Facial symmetry is considered as one of the determinants for open reduction and internal fixation of condylar fractures [5,12,16 27,28 ,29]. Hypothesis being that the condylar fractures result in loss of vertical height, leading to facial asymmetry. Our results showed reduction in ramal height on the fractured side by 3.25 ±0.60mm (pre-treatment) and further reduction in the ramus height by 1.15 mm at the end of 12 months. Though the facial asymmetry at the end of 12 months was significant, it could not be attributed entirely to loss of ramal height. The correlation between ramal height and facial symmetry was positive, but weak. Similar correlation was also noted between ramal height and condylar displacement in coronal and sagittal plane. Through this radiographic study we would like to hypothesise that a pre-treatment reduction of ramal height on fractured side by 3.25mm , in unilateral condylar fractures can be treated non-surgically using arch bars and guiding elastics without much influence on facial symmetry. In our study, the maximum follow-up period was 12 months which showed similar results as of 6^{th} month follow-up period. It will be interesting to understand the progression of these changes on a long-term basis. This, we feel is a limitation of our study. Use of conventional 2-dimensioal radiographs has been another drawback of our study. CT scans

would allow for more accurate results by eliminating factors such as magnification and manual errors during measurements.

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Declaration of interest:

All authors hereby made a joint declaration that we have no conflict of interests. Appropriate ethical guidelines have been observed and informed consent from patients have been taken. The research has not been and will not be submitted to any other journal simultaneously. All authors have read the manuscript and have agreed to submit the paper to the Journal of Oral and Maxillofacial Surgery in the present format.

Ethics statement/confirmation of patient permission

Institutional review committee approval was taken for this prospective study. Patient permission obtained.

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TABLES

Table: 1 Sample characteristics

Gender	
Male	22
Female	3
Location of condylar fracture	
Head	3
Neck	4
Subcondylar	18
Side	
Right	10
Left	15
Location of mandibular fracture	
Rt parasymphysis + Lt condyle	8
Lt parasymphysis + Rt condyle	10
Rt body + Lt condyle	3
Isolated condylar fracture	4

Parameters	Pre-treatment Mean ± SD	Immediate post-treatment Mean ± SD	3rd month follow-up Mean ± SD	6th month follow-up Mean ± SD	12th month follow-up Mean ± SD
Ramus height (non-# minus # side)	3.25 ± 0.60 mm p = 0.1680	3.25 ± 0.60 mm p = 0.1680	3.95 ± 0.83 mm p = 0.1011	4.40 ± 0.82 mm p = 0.688	4.40 ± 0.82 mm p = 0.688
Overall P value	- -		P<0.0062*	P<0.0001*	
Facial symmetry (non-# minus #side)	1.55 ± 0.22 mm p = 0.2881	1.55 ± 0.22 mm p = 0.2881	2.45 ± 0.17 mm p = 0.1014	2.70 ± 0.16 mm p =0.0718	2.70 ± 0.16 mm p =0.0718
Overall P value	- -		P<0.0049*	P<0.0005*	
Condylar displacement in coronal plane (non-# minus # side)	-3.10° ± 4.51° p = 0.1658	-2.55° ± 3.58° p = 0.2731	-1.98° ± 3.08° p = 0.3746	- 1.93° ± 3.01° p = 0.3840	- 1.93° ± 3.01° p = 0.3840
Overall P value	- P=.323		P=.183	P=.165	
Condylar displacement in sagittal plane (non-# minus # side	-3.53° ± 2.25° p = 0.2113	-2.58° ± 1.64° p = 0.3400	-1.98° ± 1.18° p = 0.4654	-1.43° ± 0.85° p = 0.6062	-1.43° ± 0.85° p = 0.6062
Overall P value	-	P=.183	P=.060	P=.037	

*p<0.05 is significant

Table 2: Changes in ramus height, facial symmetry and condylar displacement

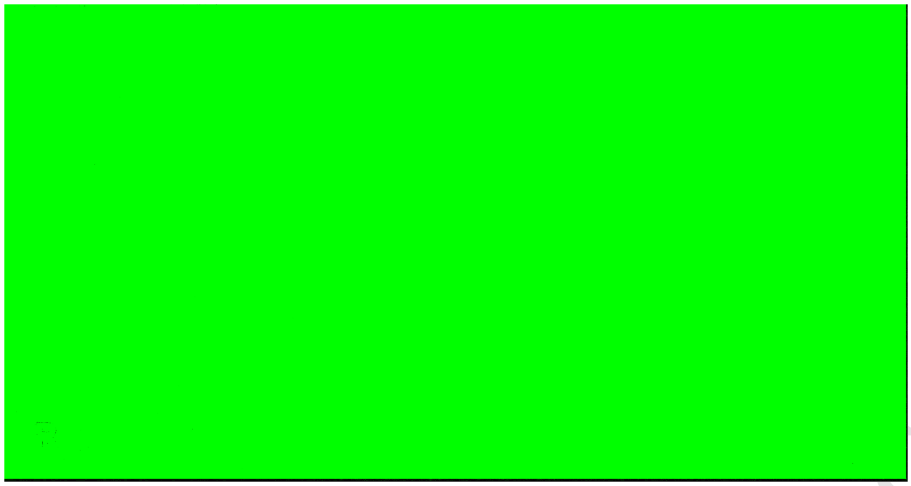
Figure legends:-

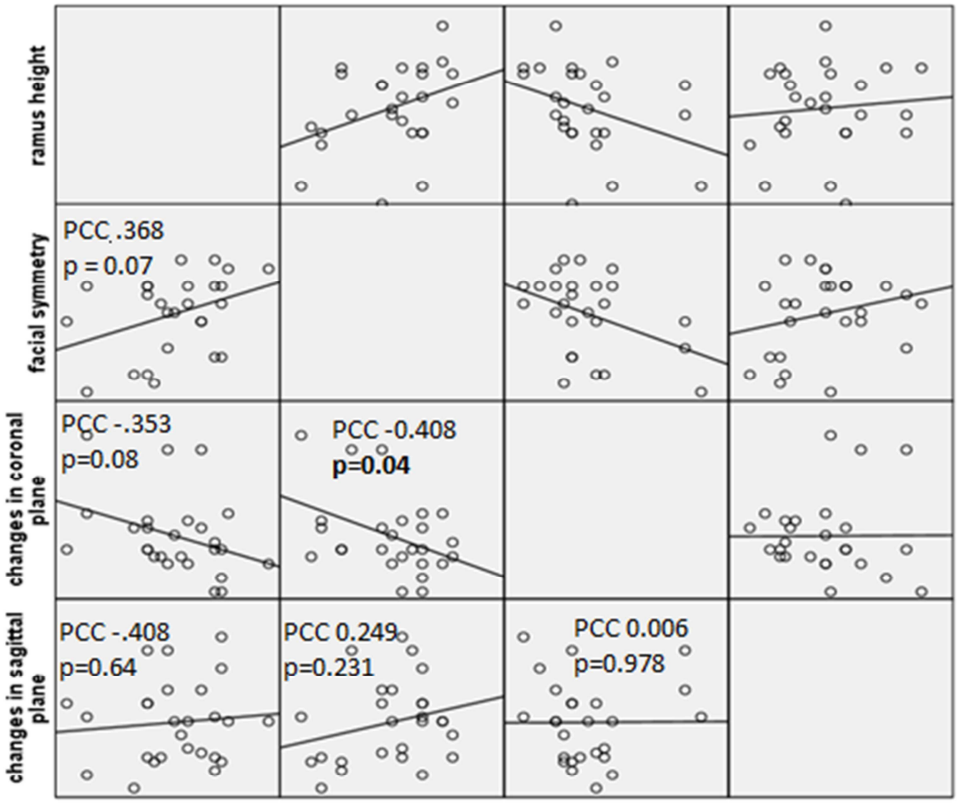
Fig.1:- Panoramic imaging view showing measurement of ramus height and condylar displacement in sagittal plane

Fig.2 :- PA view showing measurement of vertical facial asymmetry.

Fig.3 :- Reverse Towne's projection view showing measurement condylar displacement in coronal plane

Fig.4 :- Correlation between ramus height, facial symmetry, changes in coronal and sagittal planes at 12^{th} month interval





* PCC- Pearson correlation coefficient, p= p value