

Assessment of Treatment Outcomes Using Centrographic Analysis of Skeletal Class II Malocclusion

Dr. Janani Jayapal, BDS^{1*}, Dr. Priyanka Venkatasubramanian, BDS², Dr. Sanjay Sundararajan, BDS, MDS³, Dr. Ratna Parameswaran, BDS, MDS⁴, Dr. Devaki vijayalakshmi, BDS, MDS⁵

¹Post graduate, Dept of Orthodontics and Dentofacial Orthopedics Meenakshi Ammal Dental College, Tamil Nadu 600095, India

²Postgraduate, Dept of Orthodontics and Dentofacial Orthopedics, Meenakshi Ammal Dental College, Tamil Nadu 600095, India

^{3,4}Professor, Dept of Orthodontics and Dentofacial Orthopedics, Meenakshi Ammal Dental College, Tamil Nadu 600095, India

⁵Professor & HOD, Dept of Orthodontics and Dentofacial Orthopedics, Meenakshi Ammal Dental College, Tamil Nadu 600095, India

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*Corresponding author: Dr. Janani Jayapal

Abstract

Aim: The main objective of the study is to assess and compare the skeletal and dental changes obtained before and after treatment using centrographic analysis in patients with class II skeletal base using three different treatment modalities - Functional, Fixed Functional and Surgical (BSSO advancement). **Materials and methods:** A sample of 240 retrospectively collected pre-and post-treatment lateral cephalograms of class II malocclusion treated by orthodontics or orthodontic-surgical combined approach are included. The samples are grouped as Group I - Functional appliances (Twin Block appliance), Group II - Fixed functional appliances (AdvnSync II) and Group III - Surgical (BSSO advancement). The lateral cephalograms are traced and analysed using Centro-graphic analysis on FACAD 3.10 (Ilexis AB, Sweden). The post-treatment cephalograms are analysed to compare the treatment outcomes amongst the groups. **Results:** The results show high statistical significance in post-treatment class II skeletal correction among the three groups — also, a sharp reduction in the prognathic maxilla in the fixed functional group. The post-treatment mandibular prognathism was observed in the functional and surgical group. In terms of vertical component, the most significant neutral position of FC was found to be in the fixed functional group. **Conclusion:** This study primarily establishes a non-numerical method of evidence of highly significant mandibular changes were observed across the three groups. The most effectively treated subjects were found to be of the BSSO advancement group followed by functional and fixed functional groups, respectively.

Keywords: Non-numerical analysis, Centrographic analysis, Class II skeletal base, Functional, Fixed functional, bilateral sagittal split osteotomy.

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INTRODUCTION

Lateral cephalograms have been used by orthodontists for over 60 years to evaluate growth of the cranium and effects of treatment. Broadbent used the cephalometer, as it was called, to study growing children over time. He developed a method of superimposition of successive films whereby landmarks were identified and geometrically related. His sequential analysis of lateral radiographs was the first longitudinal perspective on cranial growth. Since then, many cephalometric analyses and their limitations have been described [1-4].

To establish reliability in cephalometric determinations, orthodontists have scrutinized the lateral anatomic representation by applying many

analytical methods, including lines, angles, arcs, triangles, squares, and rectangles. Measurements often represent conflicting interpretations and do not rationally depict growth patterns known to exist. So, non-numerical analyses have been developed to avoid comparisons of patients with normative values [5, 6].

A cephalometric superimposition is an analysis of lateral cephalograms of the same patient taken at different times. These superimpositions are used to evaluate a patient's growth pattern between different ages and to evaluate changes in the dentoalveolar and basal relationships after a course of orthodontic or surgical treatment. However, if such superimpositions are to be meaningful, the appropriate procedures must be executed in a technically accurate and biologically sound manner [2].

The centroid analysis was first introduced by Johnson as a non-numerical method of assessing skeletal changes and it was later modified by Fishman in the year 1997. In the original centrographic analysis, Johnson described the use of the center of gravity as a fixed reference point. The centrographic analysis abates the time and effort and reduces the task to the construction of four centroids with common and simple methods of tracing and landmark identification, with no angles to measure and no normative values to compare [2].

The Centrographic analysis is unique to each patient; it supplies independent identification of antero-posterior positions of the maxilla and the mandible, vertical facial proportion inequalities, and a stable reference plane, which can be used for longitudinal cephalometric superimposition. Centroid being the center of a 3-dimensional object was chosen to be reliable in studies done with centrographic analysis. Four triangles are drawn which represents the upper face, lower face, total face and cranium. Much information can be obtained from the 4 triangles and their respective centroids. It aids in the evaluation of facial form graphically without the need for potentially invalid numerical standards of reference [1-4].

Previous studies on centrographic analysis have established a positive reliability and validity of this technique [3, 6, 7]. But no data is available comparing the pre and the post changes using centrographic analysis. Hence, the purpose of the present study is to evaluate the pretreatment and post treatment changes in patients with class II skeletal base who were treated with functional, fixed functional and surgical treatment modalities using centrographic analysis.

MATERIAL & METHODS

This retrospective study was performed on a pre and post treatment selected sample of 120 lateral cephalometric radiographs of skeletal class II orthodontic patients (35males and 40females). The samples were grouped as Group I - treated by functional appliances, Group II - treated by fixed functional appliances and Group III - treated by surgical mandibular advancement using bilateral sagittal split osteotomy procedure with no age restrictions. This study was carried out from the Department of Orthodontics & Dentofacial orthopaedics, Faculty of Dentistry, Meenakshi Ammal Dental College, Chennai.

The records included in this study followed the inclusion criteria of:

- A full complement of permanent teeth excluding the third molars.

- No significant medical history that would affect the growth and development of the bone and no history of trauma.
- No deformity in the nasomaxillary complex.
- No previous history of orthodontic treatment or maxillofacial surgery.

CENTRO-GRAPHIC ANALYSIS

The centroid analysis as described by Fishman was adopted [2]. This technique uses an adaptation of three triangles representing the face. For each triangle, the centroid was constructed by intersection of two or three planes derived by connecting a triangular vertex to the midpoint of the opposing side. This centroid illuminates the center of gravity or mass of this three-dimensional object on a two-dimensional plane. The following three centroids are plotted on the lateral cephalograms

- Upper centroid (UC) for the upper face triangle. [(Ba- N- A) triangle]
- Lower centroid (LC) for the lower face triangle. [(Ba- A- Gn) triangle]
- Facial centroid (FC) for the total face triangle. [(Ba- N- Gn) triangle]

Centro-graphic horizontal skeletal evaluation

The horizontal assessment of maxillary and mandibular complexes is done using the centroids UC and LC and their relationship to FC.

- The UC is evaluated through its position - posterior or anterior to FC and recorded as maxillary retrognathism or prognathism.
- The LC is evaluated through its position - posterior or anterior to FC and recorded as mandibular retrognathism or prognathism.

Centro-graphic vertical skeletal evaluation:

The vertical position of FC to a line formed by Ba-A plane gives the vertical harmony of the face.

- The location of FC directly on the Ba- A plane is regarded as neutral.
- The location of FC inferior to the Ba- A plane is regarded as a Long face.
- The location of FC superior to the Ba- A plane is regarded as a Short face.

The following evaluations was analysed on pre and post treatment lateral cephalograms and compared to assess the treatment outcomes amongst the three groups using the FACAD 3.10 (Ilexis AB, Sweden) digital orthodontic tracing software.

Reliability

All cephalometric radiographs used in this study were traced and analyzed by the same operator and checked by the supervisors. To minimize the errors, landmark identification was rechecked by the same

operator. To assess the intra-examiner reliability, 20 cephalometric radiographs were randomly selected, retraced and reanalyzed after 8 weeks after the first measurement. A paired sample t- test was applied to the first and second measurements. It was found that the difference between the first and second measurements of the 20 radiographs was insignificant.

STATISTICAL ANALYSIS

The collected data were analyzed using the IBM SPSS version 19.0 (IBM Corp.) with Chi-square test to compare the differences between pre- and post-treatment outcomes of centrographic analysis. Null hypothesis was no difference between pre- and post-treatment outcomes amongst each group. The statistically significant level was set at $p < 0.05$.

RESULTS

The results as per centrographic analysis of pre and post skeletal class II orthodontic patients are tabulated (Table.1-6). The class II skeletal correction was a key feature seen from the results of the study (95%). Comparing the pre and the post treatment groups, there exists a statistically significant reduction

in maxillary prognathism post-treatment in fixed functional subjects (12.5%) ($p=0.052$).

The mandibular component was assessed using the lower centroid (LC) in relation to facial centroid (FC). The anterior position of LC to FC indicating the prognathic mandible is not evident in all three groups. In functional appliances and BSSO advancement group (5%) the mandible showed more forward positioning than the fixed functional group, post treatment. The mandible in all the three groups has shown highly statistically significant changes in post-treatment outcomes compared to pre-treatment. The BSSO advancement group ($p=0.001$) showed the most advancement followed by functional appliances group ($p=0.021$) and then fixed functional appliances group ($p=0.041$).

The evaluation of vertical discrepancies through the position of FC in relation to Ba-A plane by chi-square test, points out an overall statistical increase in neutral position of FC in all three groups. The fixed functional group have shown to achieve a statistically significant change to neutral position of FC (56.5%) ($p=0.001$).

Table-1: Pre-treatment relationship between anteroposterior positions of UC to FC

PRE-TREATMENT	MAXILLARY RETROGNATHIC		MAXILLARY PROGNATHIC	
	YES n (%)	NO n (%)	YES n (%)	NO n (%)
FUNCTIONAL APPLIANCE (TWIN BLOCK)	3 (7.5)	37 (92.5)	17 (45.94)	23 (54.05)
FIXED FUNCTIONAL (AdvnSync II)	1 (2.5)	39 (97.5)	11 (28.20)	29 (71.79)
BSSO Advancement	0	40 (100)	7 (17.5)	33 (82.5)

Table-2: Pre-treatment relationship between anteroposterior positions of LC to FC

PRE-TREATMENT	MANDIBULAR RETROGNATHIC		MANDIBULAR PROGNATHIC	
	YES n (%)	NO n (%)	YES n (%)	NO n (%)
FUNCTIONAL APPLIANCE (TWIN BLOCK)	38 (95)	2 (5)	0	40 (100)
FIXED FUNCTIONAL (AdvnSync II)	37 (92.5)	3 (3.75)	0	40 (100)
BSSO Advancement	40 (100)	0	0	40 (100)

Table-3: Pre-Treatment relationship between vertical positions of FC

PRE-TREATMENT	INFERIOR n (%)	SUPERIOR n (%)	NEUTRAL n (%)
FUNCTIONAL APPLIANCE (TWIN BLOCK)	8 (20)	19 (47.5)	13 (32.5)
FIXED FUNCTIONAL (AdvnSync II)	3 (8.10)	27 (72.97)	10 (27.07)
BSSO Advancement	16 (40)	21 (52.5)	3 (7.5)

Table-4: Post-treatment relationship between anteroposterior positions of UC to FC

POST-TREATMENT	MAXILLARY RETROGNATHIC		MAXILLARY PROGNATHIC	
	YES n (%)	NO n (%)	YES n (%)	NO n (%)
FUNCTIONAL APPLIANCE (TWIN BLOCK)	3 (7.5)	37 (92.5)	14 (37.83)	26 (62.16)
FIXED FUNCTIONAL (AdvnSync II)	5 (12.5)	35 (87.5)	6 (12.82)	34 (87.17)
BSSO Advancement	0	40 (100)	7 (17.5)	33 (82.5)

Table-5: Post-treatment relationship between anteroposterior positions of LC to FC

POST-TREATMENT	MANDIBULAR RETROGNATHIC		MANDIBULAR PROGNATHIC	
	YES n (%)	NO n (%)	YES n (%)	NO n (%)
FUNCTIONAL APPLIANCE (TWIN BLOCK)	5 (12.5)	35 (87.5)	2 (5)	38 (95)
FIXED FUNCTIONAL (AdvnSync II)	14 (35)	26 (65)	0	40 (100)
BSSO Advancement	7 (17.5)	33 (82.5)	2 (5)	38 (95)

Table-6: Post-Treatment relationship between vertical positions of FC

POST-TREATMENT	INFERIOR n (%)	SUPERIOR n (%)	NEUTRAL n (%)
FUNCTIONAL APPLIANCE (TWIN BLOCK)	11 (27.5)	6 (15)	23 (57.5)
FIXED FUNCTIONAL (AdvnSync II)	1 (2.5)	13 (32.5)	26 (56.5)
BSSO Advancement	18 (45)	5 (12.5)	17 (42.5)

DISCUSSION

The centographic analysis employs a point called centroid which forms the two dimensional geometrically derived representation of the center of mass of a three-dimensional object such as a patient's skeletal pattern [1]. This study adopts a method of centographic analysis put forth by Fishman which lays down a matrix of four triangles representing the maxilla, mandible, total face, and cranium derived from anatomic skeletal landmarks [2]. This method provides clinicians with simplified tracing techniques to assess the maxillomandibular relationship. The centroid derived in this study was found to be the most reliable point compared to various other cephalometric landmarks. And the human faces are regarded as most pleasant when the upper, lower and the facial centroids fall on the same vertical plane [3].

To the best of our knowledge, this study is the first attempt of utilizing centographic analysis to assess the outcomes of an orthodontic treatment using all the three modalities in Class II skeletal treatment – functional, fixed functional and surgical. Previous

research involving the centographic analysis was usually restricted to assessing the reliability of centroid and the evaluation of morphological features [4-7].

The past research even includes the complex incorporation of numerical methods along with centographic analysis which is predominantly non-numerical to identify effects on the timing of orthodontic treatment. This study utilizes the non-numerical method to evaluate skeletal facial balance from 240 pre-and post-treatment lateral cephalograms of skeletal class II malocclusion, treated by functional, fixed functional and BSSO advancement subjects. Also, this study aids to assess and compare the outcomes of skeletal facial balances of these patients in depth.

The results of this study shows a predominant feature in relation to the maxillary position evaluated using UC relation to FC, The maxillary position is predominantly protrusive rather very rarely retrusive in skeletal class II which agrees with the results of past researchers[8, 9]. The results of mandibular position evaluated by LC to FC are in records with the past

studies indicating a mandibular retrusion being the most common feature to skeletal class II malocclusion [10,11].

The comparison to pre and post-treatment results of the functional appliance group in this study are in agreement with many previous studies which have reported significant mandibular retrusion correction with twin block appliance. However, there is a significant reduction in superior position of FC in this study which was differing from the results of the study by Mills in 1998[12-14].

The results in this study evaluating the antero-posterior position of UC in relation to FC in fixed functional group, has a oneness with the results of study by Jayachandran *et al.* 2016, there exists an increase in the posterior movement of UC in regards with fixed functional appliance compared with other groups. However, there is reduction in anterior movement of LC in Fixed function group compared with other subject groups [15, 16].

The study results evaluating the surgical treatment approach involving BSSO advancement in skeletal class II malocclusion shows movement of LC anteriorly and reduced shortening of face which is in concordance with the study done by Strom in 2011. Also, when compared to the other groups, the BSSO advancement shows higher anterior LC movement which is also similar to the results from the study by Colin in 2003. The overall inter-group comparison shows better treatment results with surgical approach as compared with functional and fixed functional appliances [17-19].

This retrospective study using the centroid analysis provides a key non-numerical platform to compare and assess both orthodontic and orthodontic-surgical treatment approaches in skeletal class II malocclusion. The outcomes of this study evaluating and comparing the pre-and post-treatment outcomes of functional, fixed functional appliances, and surgical intervention on skeletal class II malocclusion provides an add on reliability comparison with previously reported data. Also, our results open up a far bigger controversy relating better treatment results being achieved with orthodontic-surgical approach as compared with orthodontic approach only in correcting skeletal class II malocclusion.

CONCLUSION

Post treatment sagittal parameters indicates that

- Maxilla was less prognathic in case of fixed functional group followed by functional and BSSO advancement groups.
- Mandibular advancement was more pronounced in BSSO advancement group followed by functional group and fixed functional groups.

Post treatment vertical parameters indicates that

- Shortening of maxilla was evident in fixed functional group compared to functional and BSSO advancement groups.
- Increase in lower third was prominent in BSSO advancement group than functional and fixed functional groups.

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