Original Research Article

To evaluate pre-treatment and post-treatment changes in lower anterior facial height in extraction and non-extraction cases-a digital cephalometric study

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Abstract:
Objective: The purpose of this present study was to evaluate pre-treatment and post-treatment cephalometric changes in the lower anterior facial height (LAFH) in Class I all first premolar extraction cases and compare them with Class I non – extraction cases. **Materials and Methods:** Pre-treatment and post-treatment cephalometric radiographs of 40 Class I normo-divergent patients were selected and divided into two groups i.e extraction and non-extraction groups. The extraction group included 20 patients (12 females and 08 males; pre-treatment age, 17.4 +/- 3.89 years, treatment duration 24 +/- 5 months) and non-extraction group also included 20 patients (11 females and 09 males; pre-treatment age, 18.3+/- 3.61 years, treatment duration 19 +/- 5 months). The linear and angular measurements were selected and measured with the help of NEMOCEPH® software to see the changes in LAFH. **Results:** The results obtained revealed that there was a significant increase in LAFH in non-extraction group and no significant change in LAFH in extraction group, although there was no significant difference in facial height when both the groups were compared**. Conclusion**: Thus, it can be concluded that both treatment strategies when used judiciously with good anchorage and vertical control do not lead to any significant increase in vertical facial dimension.

Keywords: Lower anterior facial height, NEMOCEPH® , Normo-divergent, Extraction, Cephalometric radiographs, LAFH, Non extraction.

INTRODUCTION

Extraction of teeth has always been a controversial topic right from the Angle era to modern times. Among the various reasons for the removal of permanent teeth, the two major reasons are to reduce bi-maxillary protrusion and for the correction of tooth size - arch length discrepancy. Apart from these two reasons, there is a third and seldom under appreciated reason for permanent tooth extraction is in order to control the vertical dimension.[1]The vertical disturbances can be of two types, one being in which the anterior teeth fail to contact each other, or open bite and the other condition being in which there is an excessive vertical overlap of the anterior teeth, or deep bite.[2]In order to correct the above mentioned vertical disturbances, be it open bite or deep bite, it is suggested by several authors that movement of the posterior teeth can be used to treat vertical disturbances. The rationale for such treatment is often based on the 'occlusal wedge hypothesis'.

According to this hypothesis, the dentoalveolar apparatus can be presumed to be an occlusal wedge, so when bicuspids and molars are distalized or extruded there is an opening of bite and on the contrary when molars are mesialized after extraction of bicuspids there is deepening of bite. This hypothesis seems to be logical from a biomechanical point of view but orthodontic treatment is performed in an oral biological environment which has its own complexities. So, it doesn't come with a surprise that there is a difference in opinion among various authors when it comes to the validity of this hypothesis.

One group of authors suggest that extraction and subsequent protraction in order to close space causes anti-clockwise rotation of mandible leading to correction of open bite and a resulting decrease in vertical facial height, more specifically the lower anterior facial height (LAFH).[3-5] On the other hand, another group states that there is no change in the LAFH and on the contrary may sometimes cause temporomandibular joint (TMJ) problems due to overclosure of the mandible .[6-12]The LAFH is the vertical distance between the anterior nasal spine (ANS) and the Menton (Me) points. The two main factors which can affect its height are the increase or decrease in the bone deposition in the baso-alveolar bone through the process of remodelling and other being the variation in the eruption of teeth. It has been proposed by some authors that orthodontic treatment causes an alteration in the lower facial height by extraction or non-extraction treatment philosophy, on the contrary other authors claim that orthodontic treatment doesn't cause any change in LAFH. Thus, in order to accurately evaluate vertical problems involving skeletal and dental components cephalometric assessment acts as an important tool.[2]

Standardized cephalometric radiographs help us to diagnose and record pre-treatment skeletal and dental relationships and compare them with post treatment radiographs and evaluate the changes due to orthodontic treatment.[13,14] Although, this method of cephalometric tracing is widely used, it has several drawbacks ranging from being time consuming to increased chances of errors in landmark identification, tracing and measurement. Thus, with the advent of computers in orthodontics many of the problems encountered by the traditional methods have been solved as digital cephalometric tracing reduces the frequency of inaccuracies due to operator fatigue, provides standardized, fast, and effective evaluation of lateral cephalograms. There are several advantages of using digital cephalometric software notably - several analyses can be performed simultaneously, helps in generating treatment predictions, allows superimposition of images, digital record keeping which overcomes the problem of film deterioration and lastly it is easy to use.[15]The linear parameters are much more affected by magnification error in cephalogram in comparison to angular parameters like Y-axis angle, MM angle, MP angle (Fig 1), that's why we use angular parameters along with linear parameter (ANS – Me) & U6-PP, L6-MP to assess changes in pre-treatment and post-treatment LAFH (Fig 2).

Hence, the purpose of this present study was to evaluate pre-treatment and post-treatment cephalometric changes in the lower anterior facial height in Class I all first premolar extraction cases and compare them with Class I non – extraction cases.

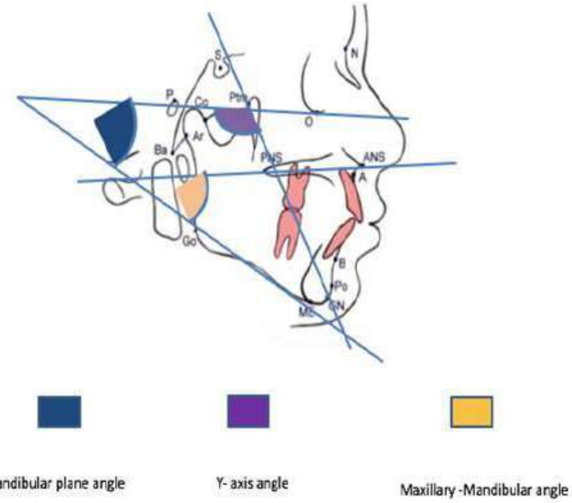

Figure 1: Angular parameters to measure LAFH.

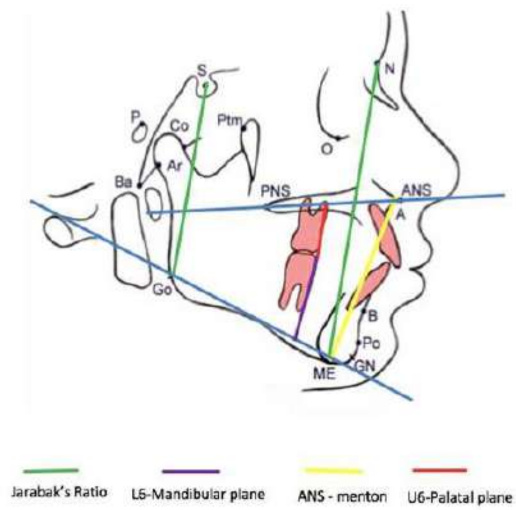

Figure 2: Linear parameters for LAFH.

MATERIALS AND METHOD

Materials (Fig 3,4)

Figure 3. Cephalostat (PlanmecaProline XC™)

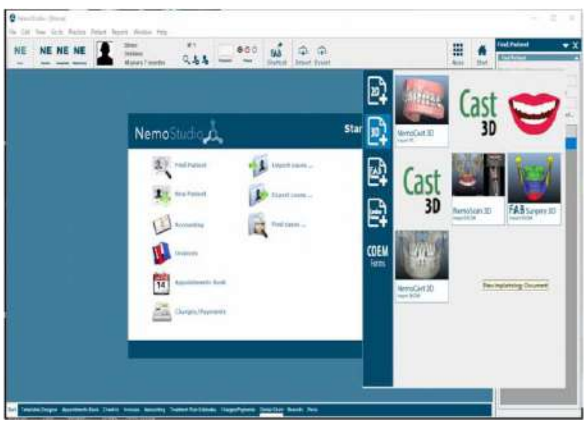

Figure 4. NEMOCEPH® ORTHODONTIC SOFTWARE

In this retrospective study, pre-treatment and post-treatment cephalometric radiographs of 40 Class I normo-divergent patients were selected from the available records of 84 patients which met the selection criteria. Master 2.0 software was used for sample size calculation and the power of the study was taken to be 80% and Confidence Interval (C.I.) was taken to be 95%. The sample size calculation was done as per the article by *Hans et al*. The sample size was estimated to be a minimum of 20 patients. The obtained records were divided into two groups' i.e extraction and non-extraction groups. The extraction group included 20 patients (12 females and 8 males; pre-treatment age, 17.4 +/- 3.89 years, treatment duration 24 +/- 5 months) and non-extraction group also included 20 patients (11 females and 9 males; pre-treatment age, 18.3+/- 3.61 years, treatment duration 19 +/- 5 months with minimal crowding). All subjects were treated by using Damon Q metal brackets with banding till second molars in order to increase anchorage along with the use of transpalatal arch and consolidation of posterior segments. In all the extraction cases Class I (intra-maxillary force) force with the help of Class I elastics was used to close the extraction spaces. After the initial selection, all X-rays were traced by the same investigator and landmarks were identified & all cephalometric measurements (3 angular and four linear) used in this study; Y-axis angle, MM angle, MP angle, ANS – Me, U6-PP, L6-MP & Jarabak ratio were made with the NEMOCEPH® software on a computer and the mean values of those measurements were calculated and statistically compared with post treatment values (Fig 5,6).[16]

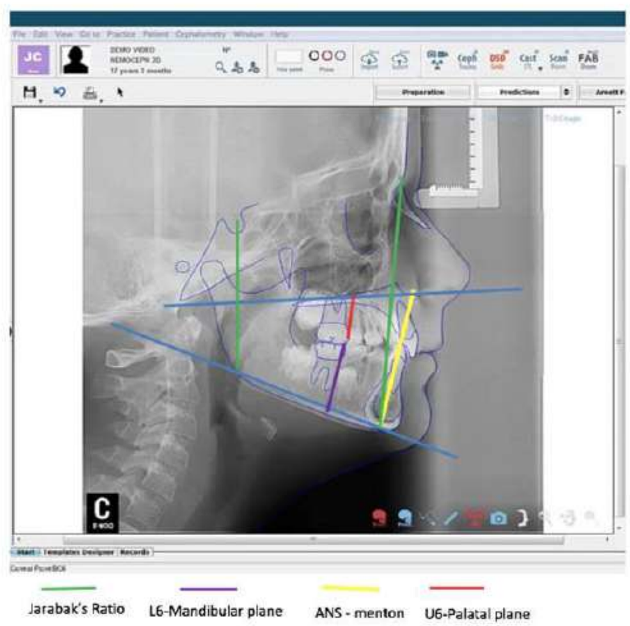

Figure 5: Linear parameters to measure LAFH.

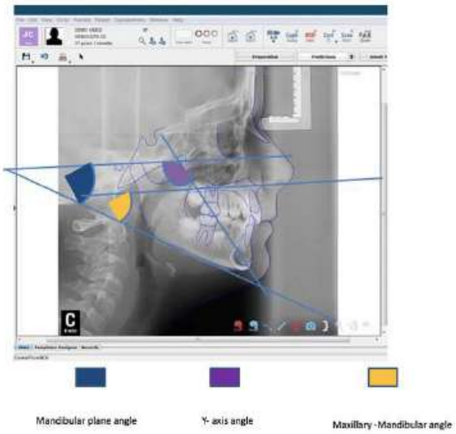

Figure 6: Angular parameters to measure LAFH.

In order to rule out bias intra Class correlation coefficient has been done for both groups that were traced at the same time by the same operator and pre-treatment and post-treatment cephalograms of 10 randomly selected patients were traced by the same operator to eliminate memory bias within duration of a month.

Selection criteria

Inclusion criteria:

1. Patient with age between 15 to 25 years.
2. The subjects with full complement of teeth upto first molars in maxillary and mandibular arches without any craniofacial abnormality.
3. Class I normo-divergent malocclusion patients (SN-GoGn, 32°+/-1°).
4. Do not have severe antero-posterior discrepancy (0° <ANB <5°)
5. Vertical discrepancy (0 mm <overbite < 6 mm)

Exclusion criteria: Patients were excluded from the study if they presented with

1. Previous history of orthodontic treatment.
2. Congenitally missing teeth/supernumerary teeth.
3. Patient with history of trauma.
4. Facial asymmetry.
5. Patients with craniofacial syndromes.
6. Patients treated with fixed functional appliances.
7. Patients treated with myofunctional appliances.
8. Patients treated with head gear.
9. Use of Temporary anchorage devices.

RESULTS

There was a normal distribution of all the variables for both extraction and non-extraction groups in the study (Table 1).

Table 1: Normal distribution of all the variables for both extraction and non-extraction group

	Groups	Shapiro-Wilk		
		Statistic	df	p-value
Jarabak pre	Extraction	0.944	20	0.284
	Non-Extraction	0.913	20	0.073
Post	Extraction	0.965	20	0.658
	Non-Extraction	0.920	20	0.098
Pre-post	Extraction	0.948	20	0.343
	Non-Extraction	0.935	20	0.193
L6 MP pre	Extraction	0.945	20	0.298
	Non-Extraction	0.936	20	0.201
Post	Extraction	0.976	20	0.868
	Non-Extraction	0.887	20	0.074
Pre-post	Extraction	0.923	20	0.113
	Non-Extraction	0.967	20	0.681
U6 PP pre	Extraction	0.949	20	0.357
	Non-Extraction	0.961	20	0.560
Post	Extraction	0.940	20	0.238
	Non-Extraction	0.947	20	0.321
Pre-post	Extraction	0.939	20	0.233
	Non-Extraction	0.973	20	0.813
ANS – Me pre	Extraction	0.946	20	0.311
	Non-Extraction	0.938	20	0.224
Post	Extraction	0.947	20	0.320
	Non-Extraction	0.958	20	0.506
Pre-post	Extraction	0.948	20	0.341
	Non-Extraction	0.940	20	0.243
MPA pre	Extraction	0.948	20	0.336
	Non-Extraction	0.926	20	0.132

Post	Extraction	0.979	20	0.915
	Non-Extraction	0.927	20	0.135
Pre-post	Extraction	0.955	20	0.451
	Non-Extraction	0.891	20	0.079
Y axis pre	Extraction	0.960	20	0.546
	Non-Extraction	0.892	20	0.080
Post	Extraction	0.936	20	0.203
	Non-Extraction	0.928	20	0.140
Pre-post	Extraction	0.853	20	0.086
	Non-Extraction	0.923	20	0.114
MM angle pre	Extraction	0.959	20	0.532
	Non-Extraction	0.942	20	0.261
Post	Extraction	0.955	20	0.454
	Non-Extraction	0.932	20	0.168
Pre-post	Extraction	0.937	20	0.211
	Non-Extraction	0.915	20	0.080

The mean of pre-treatment, post-treatment and difference from pre to post treatment was compared between extraction and non-extraction cases using the unpaired t-test for all the parameters i.e: Jarabak ratio, L6-MP, U6-PP, ANS –Me, MPA, Y-axis and MM angle (Table 2-8 and figure 7-13).

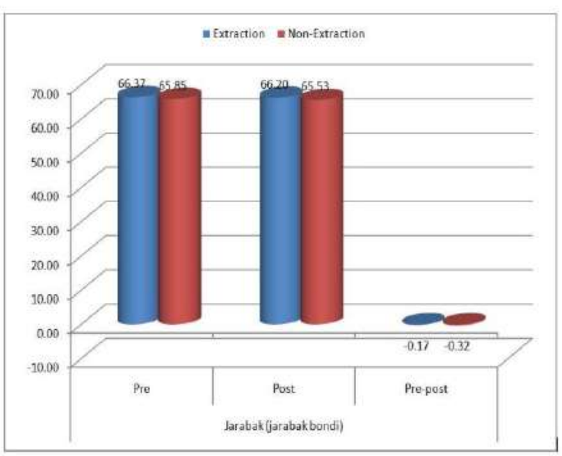

Figure7: Graphical representation of Jarabak ratio between extraction and non-extraction group using un-paired t test.

Table 2: Statistical measures of Jarabak ratio between extraction and non-extraction group using un-paired t test

	Extraction		Non-Extraction				
Jarabak	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference	t-test t value	p-value
Pre	66.37	4.82	65.85	4.04	0.52	0.370	0.714
Post	66.20	4.98	65.53	3.91	0.67	0.473	0.639
Pre-post	0.17	1.88	0.32	0.76	0.15	0.332	0.742

Unpaired t-test #non-significant difference

Table 3: Statistical measures of L6-MP between extraction and non-extraction group using un-paired t test.

	Extraction		Non-Extraction				
L6 MP	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference	t-test value	p-value
Pre	31.58	2.05	30.58	2.38	1.00	1.424	0.163
Post	32.45	2.55	31.83	2.30	0.62	0.807	0.425
Pre-post	0.88	2.75	1.26	0.68	0.38	0.601	0.552

Unpaired t-test # Non-significant difference

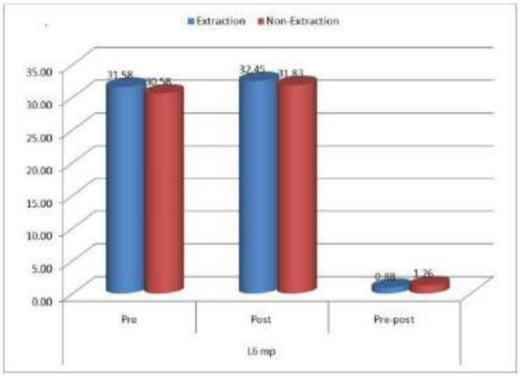

Figure8: Graphical representation of L6-MP between extraction and non-extraction group using un-paired t test.

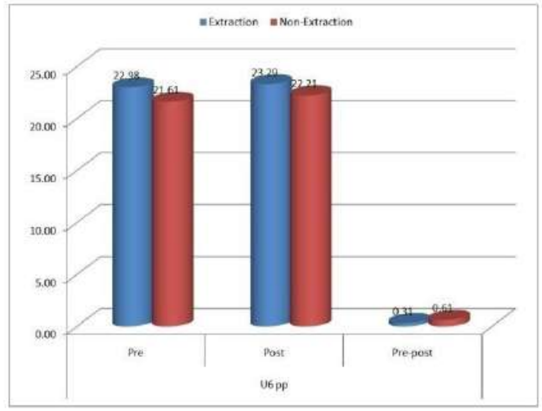

Figure 9: Graphical representation of U6-PP between extraction and non-extraction group using un-paired t test.

Table 4: Statistical measures of U6-PP between extraction and non-extraction group using un-paired t test

	Extraction		Non-Extraction				
U6 PP	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference	t-test value	p-value
Pre	22.98	1.78	21.61	2.24	1.38	1.152	0.098
Post	23.29	2.22	22.21	2.61	1.08	1.409	0.167
Pre-post	0.31	1.84	0.61	1.71	0.30	2.525	0.043*

Unpaired t-test * Significant difference

Table 5: Statistical measures of ANS –Me between extraction and non-extraction group using un-paired t test

	Extraction		Non-Extraction				
ANS – Me	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference	t-test value	p-value
Pre	64.22	3.76	60.50	6.15	3.73/3.72	1.911	0.066
Post	65.38	5.15	62.15	6.48	3.24/3.23	1.749	0.088
Pre-post	1.16	4.96	1.65	2.47	0.49	0.395	0.695

Unpaired t-test difference # Non-significant

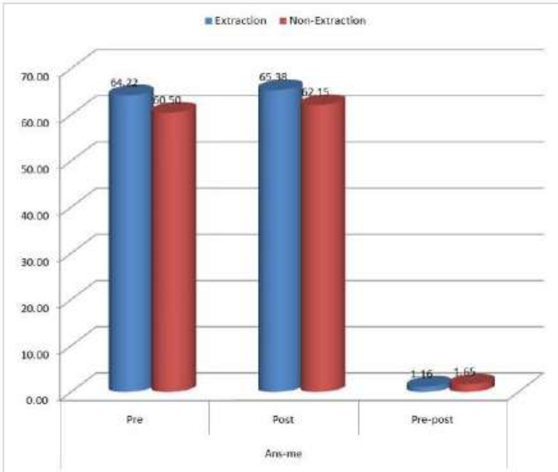

Figure10: Graphical representation of ANS –Me between extraction and non-extraction group using un-paired t test.

Table 6: Statistical measures of MPA between extraction and non-extraction group using un-paired t test

	Extraction		Non-Extraction				
MPA	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference	t-test value	p-value
Pre	25.60	5.51	21.95	6.78	3.65	1.869	0.069
Post	25.95	6.06	22.40	6.41	3.55	1.800	0.080
Pre-Post	0.35	3.65	0.45	2.28	0.10	0.104	0.918

Unpaired t-test #non-significant difference

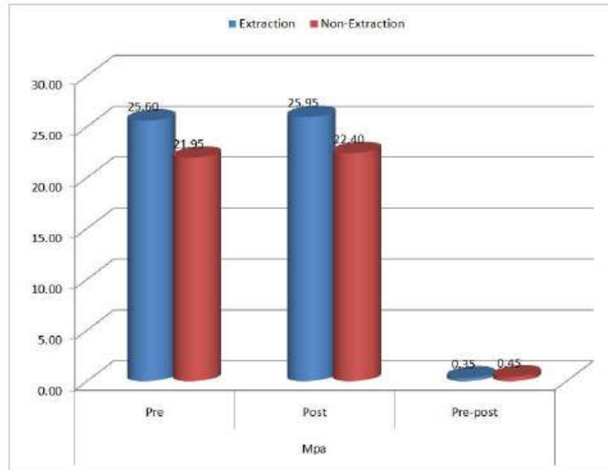

Figure11: Graphical representation of MPA between extraction and non-extraction group using un-paired t test.

Table 7: Statistical measures of Y -axis between extraction and non-extraction group using un-paired t test

	Extraction		Non-Extraction				
Y-axis	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference	t-test value	p-value
Pre	87.50	4.62	88.95	4.70	1.45	1.343	0.124
Post	87.10	4.22	89.40	5.01	2.30	1.937	0.106
Pre-Post	0.40	2.70	0.45	1.43	0.85	1.243	0.142

Unpaired t-test #non-significant difference

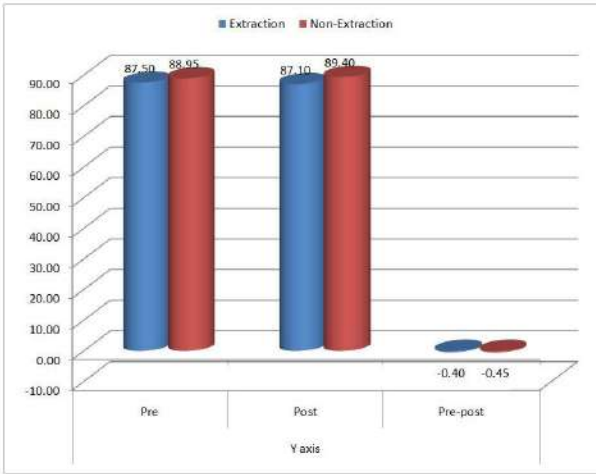

Figure12: Graphical representation of Y -axis between extraction and non-extraction group using un-paired t test.

Table 8: Statistical measures of MM- angle between extraction and non-extraction group using un-paired t test

MM-angle	Extraction		Non-Extraction				
	Mean	Std. Deviation	Mean	Std. Deviation	Mean Difference	t-test value	p-value
Pre	20.80	4.86	19.50	5.82	1.30	1.536	0.115
Post	21.45	6.05	20.45	5.78	1.00	1.604	0.117
Pre-post	0.65	2.18	0.95	1.19	0.30	1.338	0.125

Unpaired t-test * non-Significant difference

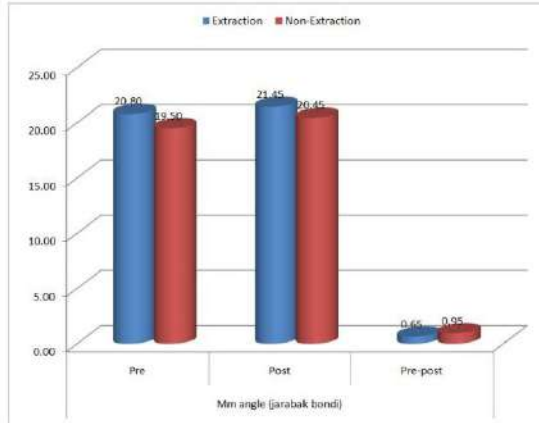

Figure13: Graphical representation of MM- angle between extraction and non-extraction group using un-paired t test.

There was no significant difference in any of the parameters, except the mean difference from Pre to post treatment was found to be significantly more among non-extraction group (Table 4 and figure 9).

The mean values of all the parameters were compared between pre- and post-treatment using the paired t-test in both extraction and non-extraction groups. No significant difference was found in both the groups except the ANS–Me and MM angle values which increased significantly from pre- to post-treatment in the non- extraction group (Table 9-10 and figure 14-15).

Table 9: Statistical analysis of cephalometric measures for pre –treatment and post –treatment in extraction group using paired t test

	Pre-treatment		Post-treatment		Mean difference	t-test value	p-value
Extraction	Mean	Std. Deviation	Mean	Std. Deviation			
Jarabak ratio	66.37	4.82	66.20	4.98	0.17	0.405	0.690
L6-MP	31.58	2.05	32.45	2.55	0.88	1.425	0.170
U6-PP	22.98	1.78	23.29	2.22	0.31	0.752	0.461

ANS–Me	64.22	3.76	65.38	5.15	1.16	1.045	0.309
MPA	25.60	5.51	25.95	6.06	0.35	0.429	0.673
Y-axis	87.50	4.62	87.10	4.22	0.40	0.662	0.516
MM angle	20.80	4.86	21.45	6.05	0.65	1.332	0.199

Paired t-test #non-significant difference

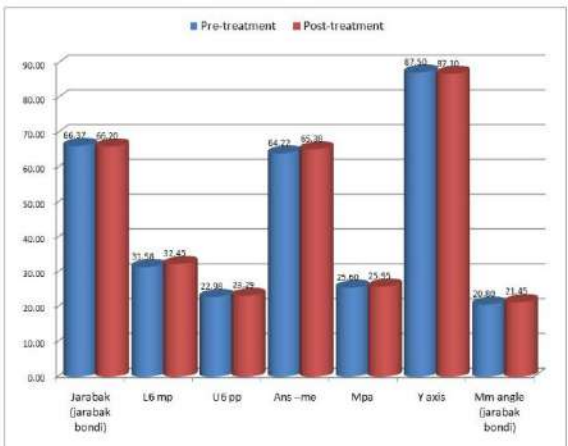

Figure14: Graphical representation of cephalometric measures for pre –treatment and post –treatment in extraction group using paired t test.

Table 10: Statistical analysis of cephalometric measures for pre –treatment and post –treatment in non – extraction group using paired t test

	Pre-treatment		Post-treatment		Mean difference	t-test value	p-value
Non-Extraction	Mean	Std. Deviation	Mean	Std. Deviation			
Jarabak ratio	65.85	4.04	65.53	3.91	0.32	1.887	0.075
L6-MP	30.58	2.38	31.83	2.30	1.26	8.233	0.061
U6-PP	21.61	2.24	22.21	2.61	0.60	1.585	0.130
ANS–Me	60.50	6.15	62.15	6.48	1.65	2.988	0.008*
MPA	21.95	6.78	22.40	6.41	0.45	0.882	0.389
Y-axis	88.95	4.70	89.40	5.01	0.45	1.406	0.176
MM angle	19.50	5.82	20.45	5.78	0.95	4.322	0.041*

Paired t-test * Significant difference

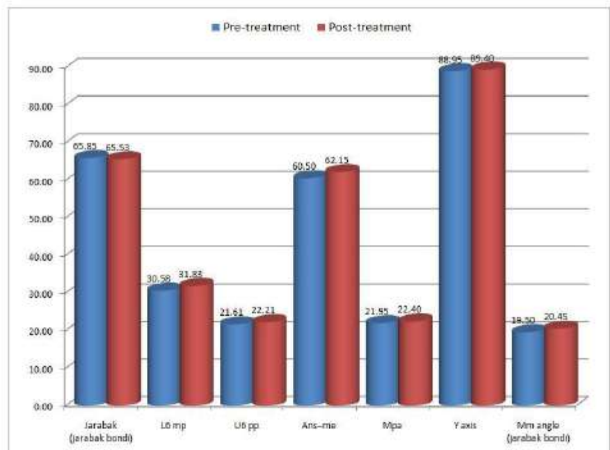

Figure15: Graphical representation of cephalometric measures for pre –treatment and post –treatment in non – extraction group using paired t test.

DISCUSSION

There has always been a lot of debate regarding the role of premolar extraction and change in the facial height. The purpose of this study was to investigate the effect of extraction of first premolars on LAFH as there is a lot of controversy when it comes to the role of premolar extraction and change in vertical height. There is a general consensus among orthodontists that pre molar extraction according to the occlusal wedge hypothesis causes an anti-clockwise rotation of the mandible and hence reduces the lower anterior facial height whereas a non-extraction treatment protocol on the contrary causes a clockwise rotation of the mandible and as a result increase in LAFH .The results obtained in this study tend to differ from the above mentioned effect of premolar extraction on facial height as no reduction in LAFH was to be found in the extraction group but there was a significant increase in LAFH in the non-extraction treatment group.

Chua et al devised a study to see whether is there any effect of the type of treatment plan on the patient's LAFH and for this one hundred seventy-four Class I and II patients were selected who were further divided into extraction and non-extraction patient groups. The outcome of the study came out that there was no notable change in LAFH in extraction group but on the contrary there was notable increase in LAFH in non-extraction group which corroborates with our findings[17].

Kocadereli et al devised a study to see whether the extraction of 1st bicuspids had any effect on the facial height. For this, two groups with forty patients each were created, one with 1st bicuspids extraction line of treatment and second with non-extraction and their cephalometric readings were recorded and compared. The results indicated that there was no significant difference in vertical height between extraction and non-extraction cases.[6] Staggers et al tested the hypothesis that removal of first bicuspids may result in a decrease of LAFH for which pre-treatment and post-treatment cephalographs of forty-five Class I patients who were treated by non-extraction treatment plan were compared with thirty-eight Class I, first bicuspids removal cases. The cephalogram were digitized and angular along with linear cephalometric parameters were evaluated and results obtained stated that there was a significant increase in LAFH in both the groups.[18]

Kim T.K et al tested the 'occlusal wedge hypothesis' which states that extraction of second bicuspids and mesial movement of molars leads to decrease in facial height in Class I malocclusion and hypo-divergent facial type. The results obtained revealed that there was no change in vertical height in either of the groups and hence declined the validity of the occlusal wedge hypothesis.[7] Hayasaki et al evaluated the changes in facial height in Class II and Class I malocclusion and found that Jarabak ratio between extraction and non-extraction treatment in both Class I and Class II patients was similar and no significant changes between the groups were found.[19]

Al nimri studied the effects of mandibular first and second premolar extraction cases on vertical facial height and concluded that although there was a mesialization of molar in the second premolar extraction group there was no significant change in the MM angle and facial height in any of the group.[20] Similarly, Hans et al devised a study see whether there was any change in LAFH after extraction of four fist molars and compared them with all 4 first premolar cases and found that no significant cephalometric changes were found in either of the group.[21]

All of the above-mentioned studies indicate similar results that premolar extraction does not have a significant impact on the vertical facial dimensions. This can be explained by the fact that most of the extractions done in Class I malocclusion are done to relieve crowding and in bi-max cases rest of the space is utilised for the retraction of anterior teeth and during this retraction if proper anchorage is maintained, there is no or very little mesialization of molars which do not produce any significant change in facial height. In the present study, all the cases selected were skeletally and dentally Class I and the extraction spaces were used to relieve crowding and retraction of anterior teeth along with anchorage preservation and vertical position maintenance of posterior teeth which led to insignificant change in facial height which was confirmed by no significant changes in angular and linear cephalometric values (Table 8).

Another important factor to take into account is seeing the effect the premolar extraction on facial height is growth. Kim et al and Harris et al advocated that change in facial height was due to the presence of residual growth in late teens.[7,22] In another study done by Taner-Sarisoy it was put forward that there was no change in the LAFH after extraction of premolars as any mesialization and reduction in facial height by the wedging effect was compensated by the growth potential in the patient. The above mentioned reason doesn't holds true in our study as the patients selected in our study were well beyond their growth potential with cervical vertebrae in stage 5 (Hassel and Farman) and hence disapproves the theory of wedging effect as there was no significant change in LAFH after extraction of premolars.[23]

Aras et al evaluated the changes that occurred in patients with open bite after orthodontic treatment and concluded that extraction of second bicuspids and first molars led to an anti-clockwise or closing rotation in AOB patients.[3] Beit P et al evaluated the changes in LAFH in all 4 premolar extraction cases and compared them with non-extraction cases and found that LAFH increased in non-extraction cases but decreased in extraction group which may be due to difference in characteristics between the study sample, hence direct comparisons between these studies is impossible.[5] Similar results were obtained when a systematic review was carried out by Kouvelis et al to see the effects of all 4 first premolar extraction on vertical height of face and was concluded that there was no evidence to claim that extraction of premolar had any effect on the facial height.[24] In a meta-analysis by Jain et al to evaluate LAFH in extraction v/s non –extraction cases it was found that there is no statistically significant effect of extraction of four first premolars on lower anterior facial height.[25]

In the present study digital cephalometry software, NEMOCEPH®, was used to avoid the disadvantages associated with conventional methods namely being more time consuming, magnification error to high-risk of errors in tracing, landmark identification, reproducibility and measurement. Moreover, angular parameters were included in addition to linear parameters to measure the changes the LAFH.[16]

The results of our study revealed that extraction of maxillary and mandibular first premolars in Class I patients did not have any significant change in the facial height which is in accordance to several studies mentioned above.

CONCLUSION

The purpose of this study was to test the hypothesis that extraction of premolars leads to reduction in LAFH due to "wedging effect" which states that in extraction cases there is mesialization of molars which leads to anti-clockwise rotation of mandible and consequently a reduction in lower anterior facial height. Thus, the following conclusion can be drawn from this study.

There is no significant change in LAFH when all four first premolar extraction protocol was followed, hence disapproving the 'occlusal wedge hypothesis.'

No significant change in vertical facial height was seen when all four first premolar extraction cases were compared with non-extraction group, concluding that the type of protocol used had a little impact on LAFH.

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