

Dento-skeletal changes between headgear-fixed and activator-fixed therapies

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أحرقت الدراسة البحثية بقياس أبعاد الرأس خلال فترة سابقة لمقارنة تغيرات العظام السن في ٦٠ أنثى من الجنس القوقازي في سن البلوغ (١٣-١٤ سنة) والآن يظهر علامات عدم تطابق في الأسنان (الغثة الثانية للمجموعة الأولى) حيث عولجوا بأسلوب القلع باستخدام وسائل علاج مختلفة وكانت ثلاثين أنثى منهم قد عولجت بالشد الخارجي للفم باستخدام كايح الفك ثم تلى ذلك العلاج بتثبيت الجهاز الذي سبق ضبطه. بينما تقلدت المجموعة الباقية أجهزة للنشط الوظيفي والتي تبعها نفس العلاج بجهاز EDGE WISE، حسدت نمو الأمام بعظام الفك السفلي وبقدر معقول وذلك بكتلتا المجموعتين مع زيادة النمو بقدر أكبر في المجموعة الثابتة وظيفياً وإلى دوران الفك إلى الخلف في أي من المجموعتين. أظهرت مجموعة التثبيت بجهاز الكايح وجود تعجيل في النمو الأمامي للفك العلوي مع تحرك مستوى الخنك إلى الإنحساء السفلي الأمامي يعزى إلى تقلد جهاز كايح الفك. وكان نقص التداخل في المجموعة الثابتة وظيفياً بسبب الزيادة في طول حسم الفك وتحرك الفواضع الأمامية العليا باتجاه الخلف بينما في مجموعة التثبيت بكايح الفك وبالإضافة إلى ماسبق هذا

A retrospective cephalometric study was undertaken to compare the dento-skeletal changes in 60 caucasian female patients aged 12 to 13 years exhibiting Class II Division 1 malocclusion and managed on a non-extraction basis by two different treatment modalities. Thirty were treated with extra-oral traction by headgear followed by pre-adjusted Edgewise fixed appliance therapy while the remainder wore activator functional appliances initially followed by similar Edgewise therapy. Skeletally, there was significant forward mandibular growth in both groups with larger increase in the functional-fixed group. The increase in lower anterior facial height which was greater in the functional-fixed group did not result in posterior rotation of the mandible in either group. The headgear-fixed group exhibited considerable restraint of forward growth of the maxilla with an anterior downward tipping of the palatal plane which was attributed to the wear of headgear. Overjet was reduced in the functional-fixed group by an increase in mandibular corpus length and incisal tipping, while in the headgear-fixed group, in addition, it was also due to maxillary restraint.

Introduction

There are different approaches to the management of Class II Division 1 malocclusions. The use of a functional appliance and fixed finishing procedure is currently gaining popularity but treatment with fixed appliances supported by headgear may also provide an effective means of correction. While the majority of studies on the effects of fixed appliances have reported dentoalveolar changes,^{1,3} skeletal changes have also been reported especially when extraoral traction had been used.^{4,5} Considerable attention has focused on the clinical effects of functional appliance both skeletally^{6,10} and dentally.¹¹⁻¹²

More importantly, cephalometric comparisons between these two treatment modalities on a non-extraction basis have proved inconclusive regarding the increase in mandibular length.^{13,14} Maxillary restraint is more evident with a combination of headgear and fixed appliance^{11,15} and more palatal tipping of upper incisors is thought to occur with fixed appliances.¹⁶ It is not uncommon to use pre-adjusted Edgewise appliances following functional therapy in the

treatment of Class II Division 1 malocclusion and indeed this study sought to identify the net effects of this combination treatment modality.

The aim of this study was to examine the dento-skeletal responses in two groups of patients with Class II Division 1 malocclusion who were treated by two non extraction treatment modalities. The first group was treated using headgear and pre-adjusted Edgewise appliance. The other group was treated with an initial phase of functional appliance which was an activator followed by similar pre-adjusted Edgewise appliance.

Materials and Methods

The sample comprised 60 female Caucasian adolescents exhibiting Class II Division 1 malocclusion and an initial minimum overjet of 7 mm. Thirty female patients were treated using pre-adjusted Edgewise appliance and extraoral traction. The remaining 30 females were treated initially by a functional appliance followed by the use of pre-adjusted Edgewise appliance. The material used for the study consisted of standardised lateral skull cephalometric radiographs in occlusion taken before treatment and at the end of fixed appliance therapy.

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Cephalometric points plotted

The points that were plotted were sella (S), nasion (N), point A (A), point B (B), pogonion (Pog), articulare (Ar), gnathion (Gn), gonion (Go), anterior nasal spine (ANS), posterior nasal spine (PNS), upper incisor edge (UIE), upper incisor apex (UIA), lower incisor edge (LIE) and lower incisor apex (LIA).

The cephalometric landmarks shown in Fig. 1 with the exception of gonion, were digitized directly from the radiograph in a predetermined sequence and the measurements were recorded and calculated using a customised computer program. Gonion was first determined by constructing and bisecting the angle between the tangents to the lower and posterior borders of the mandibular angle on a square piece of fine tracing paper secured onto the radiograph. It was then digitised in sequence. Articulare (Ar) was used in the cephalometric analysis of mandibular length as recommended by Stickel and Pancherz¹⁸ involving longitudinal studies comparing groups of subjects.

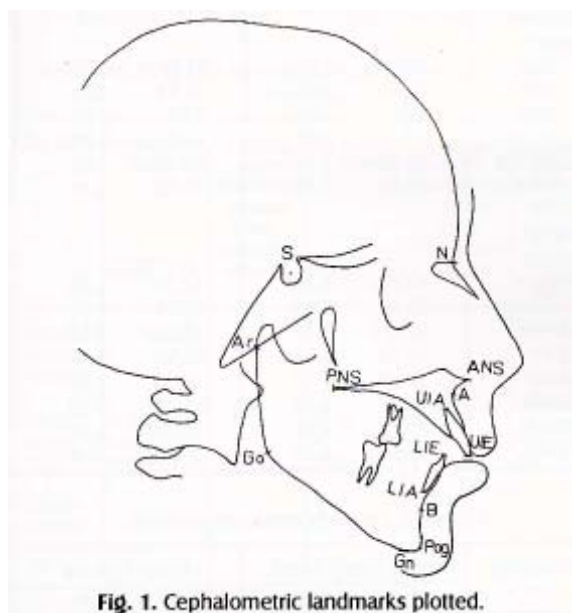


Fig. 1. Cephalometric landmarks plotted.

The maxillary plane (Mx) is the line which joins ANS and PNS while the mandibular (Md) plane is from gonion (Go) to gnathion (Gn). The maxillary mandibular planes angle (MMPA) is at the intersection of the maxillary and mandibular planes. Upper anterior facial height (UAFH) is measured from nasion (N) to ANS and the lower anterior facial height (LAFH) is from ANS to gnathion (Gn). Total anterior facial height (TAFH) is from nasion (N) to gnathion (Gn)

The horizontal reference line used was a line formed by a 7° superior rotation of the line sella nasion SN about point nasion N.¹⁹ The vertical reference line was constructed through sella perpendicular to the rotated SN line. Angular and linear measurements for skeletal and dental variables were calculated using a customised computer program which utilised the digitised cephalometric points. The statistical methods that were used to analyse the comparison of changes within each group was paired t-test and unpaired t-test for changes between the two groups.

Error of method

The error of the method was analyzed using the one paired sample t-test where P should be greater than 0.1. The value above 0.95 for index of reliability²⁰ and the value lower than 1.1 for Dahlberg formula²¹ are considered acceptable for cephalometric studies. The paired t-test was used to assess systematic bias, the index of reliability to estimate the level of random error and Dahlberg's error is a combination of both systematic and random error.²² A total of 30 radiographs were randomly selected and redigitized after 6 weeks. Since all the p-values, index of reliability and Dahlberg's formula were within the ranges mentioned above, therefore, the measurement

Table 1. Error of method.

Measurements	P-Value	Index of reliability	Dahlberg's formula
SNA	0.98	0.99	0.30
SNB	0.17	0.96	0.56
ANB	0.25	0.96	0.45
SN-Mx	0.54	0.97	0.57
MMPA	0.23	0.97	0.61
SN-Pog	0.98	0.99	0.37
UI-Mx	0.16	0.99	0.65
LI-Mn	0.59	0.98	0.70
UI-LI	0.57	0.98	0.70
OJ	0.48	0.99	0.27
OB	0.51	0.97	0.39
A-Vrl	0.28	0.98	0.53
B-Vrl	0.98	0.99	0.56
UIE-Vrl	0.88	0.99	0.42
LIE-Vrl	0.89	0.99	0.41
Ar-Gn	0.57	0.99	0.45
Ar-Go	0.15	0.99	0.43
Go-Gn	0.86	0.99	0.35
UAFH	0.21	0.98	0.36
LAFH	0.89	0.99	0.45
TAFH	0.41	0.99	0.46

errors were acceptable. (Table 1) The statistical analysis package used was MINITAB.

Results

The results have been tabulated as follows:

- Pre-treatment values between groups - Tables 2 A and 2 B
- Post-treatment values between groups-Tables 3 A and 3 B
- Treatment changes within and between groups -Tables 4 A and 4 B

Pre-treatment values between groups

The headgear/ fixed group had a pre-treatment mean age of 12.85+1.42 years and mean treatment duration of 1.70+0.51 years (Table 5). The functional-fixed group began slightly earlier at 12.03+1.06 years and slightly longer treatment with 2.19+0.65 years. In other words, these cases on the average started 9 months earlier and had a longer treatment period of 6 months.

The two groups were comparable before treatment in terms of linear and angular measurements with the exception of angle ANB. Both groups exhibited a skeletal II dental base relationship with the functional-fixed having a larger discrepancy of 6.65° as compared to 5.43° in the headgear/ fixed group ($p < 0.05$).

Table 2A. Pre-treatment comparison.

Variable	Headgear/ Fixed		Func /Fixed		Inter- group Comparison
	Mean	S.D.	Mean	S.D.	
SKELETAL					
Angular values					
SNA	82.18	4.07	82.0	3.77	ns
SNB	76.77	3.74	75.43	3.53	ns
ANB	5.43	2.19	6.65	2.27	*
SN-Mx	5.77	2.74	6.27	3.21	ns
MMPA	27.98	5.27	28.97	7.13	ns
SN-Pog	78.03	3.94	76.72	3.89	ns
Linear Values					
Ar-Go	39.92	4.10	38.63	4.27	ns
Go-Gn	68.62	4.98	67.62	3.86	ns
Ar-Gn	97.43	6.68	95.37	4.21	ns
B-Vrl	56.42	6.52	54.58	5.83	ns
A-Vrl	65.03	4.99	65.03	3.78	ns
LAFH	56.22	4.15	55.68	4.54	ns
UAFH	47.0	2.78	47.47	2.85	ns
TAFH	103.22	5.77	103.28	6.02	ns

ns = not significant * = significant at 0.05 level

Table 2B. Pre-treatment comparison.

Variable	Headgear/ Fixed		Func/ Fixed		Inter- group compar- ison
	Mean	S.D.	Mean	S.D.	
DENTAL					
Angular values					
UI-Mx	115.58	6.94	114.15	6.14	ns
LI-Mn	94.37	5.07	94.50	6.83	ns
LI-LI	122.08	8.23	122.37	9.11	ns
Linear Values					
OB	4.33	1.80	5.30	2.03	ns
OJ	7.92	1.96	8.83	2.43	ns
LIE-Vrl	62.35	6.07	61.48	4.69	ns
LIE-Vrl	70.25	5.74	70.37	4.73	ns

ns=not significant * = significant at 0.05 level

Table 3A. Pre-treatment comparison.

Variable	Headgear / Fixed		Func / Fixed	
	Mean	S.D.	Mean	S.D.
SKELETAL				
Angular values				
SNA	80.62	3.99	81.13	4.05
SNB	77.10	3.81	76.58	4.16
ANB	3.63	2.26	4.57	2.28
SN-Mx	6.52	2.82	6.75	3.75
MMPA	27.38	5.47	28.30	7.08
SN-Pog	78.55	3.86	78.03	4.74
Linear Values				
Ar-Go	42.88	5.28	42.72	3.88
Go-Gn	70.97	5.49	72.13	4.73
Ar-Gn	101.77	7.20	102.95	4.87
B-Vrl	57.76	7.36	57.55	6.76
A-Vrl	64.95	5.53	66.32	3.97
LAFH	60.22	5.05	61.30	5.38
UAFH	49.35	2.84	49.65	3.14
TAFH	109.60	6.79	109.23	10.64

Table 3B. Post-treatment comparison.

Variable	Headgear / Fixed		Func / Fixed	
	Mean	S.D.	Mean	S.D.
DENTAL				
Angular values				
UI-Mx	108.63	7.65	107.45	6.85
LI-Mn	97.82	6.88	99.27	8.33
LI-LI	126.13	6.95	125.02	10.33
Linear Values				
OB	1.98	1.15	2.22	1.06
OJ	2.67	0.95	2.55	1.03
LIE-Vrl	64.67	6.85	66.35	4.91
LIE-Vrl	67.37	7.26	68.92	5.08

Table 4A. Intra-and Inter-group comparison of treatment changes.

Variable	Headgear/ Fixed		Comparison between pre-and post treatment values	Func/ Fixed		Comparison between pre-and post treatment values	Comparison between groups of treatment
	Mean	S.D.		Mean	S.D.		
SKELETAL Angular values							
SNA	-1.57	1.47	***	-0.87	0.56	**	ns
SNB	0.33	1.12	ns	1.15	2.07	**	ns
ANB	-1.80	1.45	***	1.15	2.07	***	ns
SN-Mx	0.75	1.85	*	0.48	2.22	ns	ns
MMPA	-0.60	1.79	ns	-0.67	2.63	ns	ns
SN- Pog	0.52	1.12	*	1.32	2.05	***	ns
Linear Values							
Ar-Go	2.97	3.03	***	4.08	2.49	***	ns
Go-Gn	2.35	2.05	***	4.52	3.22	***	ns
Ar-Gn	4.33	3.30	***	7.58	3.75	***	***
B-Vrl	1.35	2.42	**	2.97	3.67	***	*
A-Vrl	-0.08	1.69	ns	1.28	1.75	***	**
LAFH	4.00	2.13	***	5.62	2.35	***	**
UIAFH	2.35	1.57	***	2.18	2.06	***	ns
TAFH	6.38	3.36	***	5.95	9.01	***	ns

ns = not significant * = significant at 0.05 level
 ** = significant at 0.01 level *** = significant at 0.001 level

Table 4B. Intra-and Inter-group comparison of treatment changes.

Variable	Headgear/ Fixed		Comparison between pre-and post treatment values	Func/ Fixed		Comparison between pre-and post treatment values	Comparison between groups of treatment
	Mean	S.D.		Mean	S.D.		
DENTAL Angular values							
UI-Mx	-6.95	7.79	***	-6.70	6.37	***	ns
LI-Mn	3.45	6.02	**	4.77	7.60	**	ns
UI-LI	4.05	9.10	*	2.65	9.51	ns	ns
Linear Values							
OB	-2.35	1.63	***	-3.08	1.99	***	ns
OJ	-5.25	2.15	***	-6.28	2.56	***	ns
LIE-Vrl	2.32	2.23	***	4.87	2.98	***	***
UIE-Vrl	-2.28	3.09	***	-1.45	2.76	**	*

ns = not significant * = significant at 0.05 level
 ** = significant at 0.01 level *** = significant at 0.001 level

Treatment changes within and between groups

Skeletal

In the functional-fixed group both SN-Pogonion and SNB increased by 1.32° and 1.15° respectively,

Table 5. Age distribution and treatment duration (years).

Group	Pre-treatment		Post-treatment		Treatment duration	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
HG-Fixed 30 females	12.85	1.42	14.56	1.24	1.70	0.51
Func-Fixed 30 females	12.03	1.06	14.22	0.99	2.19	0.65

these changes being significant at 0.1 per cent and 1 per cent level, respectively. In the headgear-fixed group, SN-Pogonion increased by 0.52° and SNB increased by 0.33°. While these angular changes were greater in the functional-fixed group, the intergroup differences were statistically non significant.

The linear measurements on the mandible showed highly significant mean increases in both groups at the 0.1 per cent level. In the headgear-fixed group, the mean increases in the total mandibular length (Ar-Gn) was 4.43 mm with increases in Ar-Go and Go-Gn by 2.97 mm and 2.35 mm, respectively. The functional-fixed group exhibited greater increases in these measurements; these being Ar-Gn (7.58 mm), Ar-Go (4.08 mm) and Go-Gn (4.52 mm). The intergroup treatment difference was significant at 0.1 per cent level for Ar-Gn and at 1 per cent level for Go-Gn.

The distances of point B from sella vertical (B-Vrl) increased in the fixed group by 1.35 mm (significant at 1 per cent level) and in the functional-fixed by 2.97 mm (significant at 0.1 per cent level). As there were significant mean increases in angular and linear measurements of the mandible, the question that arose was if any significant anterior rather than posterior rotation of the mandible resulted. Both groups exhibited mean decreases in the maxillomandibular plane angles (MMPA) by 0.60° in the fixed group and 0.67° in the functional-fixed which may indicate an anterior mandibular rotation but the results were neither clinically nor statistically significant.

Mean increases in the anterior facial height were significant at 0.1 per cent level for both groups. However, the intergroup treatment difference was significant at the 1 per cent level only for lower anterior facial height with the functional-fixed group exhibiting a greater mean increase of 5.62 mm than the headgear-fixed group of 4.00 mm.

The effect of extraoral traction on the maxilla in

the headgear-fixed group was seen in the essentially unchanged position of Point A from sella vertical (A-Vrl) and the anterior downward tipping of the maxilla as evidenced by the increase in SN-Mx by 0.750. However in the functional-fixed group, Point A was 1.28 mm more anteriorly positioned. This intergroup treatment difference was significant at the 1 per cent level.

SNA which gives an angular measurement of the spatial relationship of the maxilla decreased in both groups; the mean decrease being more in the headgear-fixed group (1.57°) than in the functional-fixed group (0.87°). As Point A was virtually unchanged in the headgear-fixed group where extraoral traction was used, any mean decrease in SNA would have been due to nasion positioned more anteriorly as a result of forward growth.

This effect of growth on nasion is also seen in the functional-fixed group but the decrease in angle SNA is partially offset by the relatively reduced restraint on forward growth of maxilla which also positioned Point A more anteriorly.

Sagittal correction was achieved to similar degrees in both groups but in different ways. In the headgear-fixed group it was by significant reduction of angle SNA (significant at 0.1 per cent) while in the functional-fixed, it was the cumulative effect of the mean decrease in SNA and the increase in SNB of 1.15° both of which were significant at the 1 per cent level.

Dental

In the headgear-fixed group, the inclination of the upper incisors to the maxillary plane (UI-Mx) decreased by 6.95° resulting in an average post treatment value of 108.63°. The distance of the upper incisor edge to sella vertical (UIE-Vrl) changed in a palatal direction by 2.88 mm. Both of these measurements for the headgear-fixed group were significant at the 0.1 per cent level. The reduction in the upper incisor inclination and its distance from sella vertical appeared partly due to incisor tipping palatally and the anterior downward tipping of the maxilla (SN-Mx increased by 0.75°) under the influence of the extraoral traction. Similar responses for the upper incisor were seen in the functional-fixed group except that the distance of the incisal edge to sella vertical changed palatally by only 1.45 mm. This intergroup treatment difference was significant at the 5 per cent level.

Both functional-fixed and headgear-fixed groups exhibited significant lower incisal labial

flaring as seen by the increase in the lower incisor inclination of 4.77° and 3.45°, respectively. There were also increases in the distance of lower incisor edge from sella vertical (LIE-Vrl) with functional-fixed showing a larger increase of 4.87 mm as compared to 2.32 mm in the headgear-fixed group. This intergroup treatment difference was significant at the 0.1 per cent level.

The increase in LIE-Vrl is due to lower incisor proclination in addition to skeletal mandibular changes. As observed earlier, there was an increase in the mandibular corpus length (Go-Gn) which would take the lower incisors further away from the sella vertical. The larger increase in Go-Gn for the functional-fixed group would contribute to the larger increase in its LIE-Vrl.

The overjet was reduced to 2.67 mm in the headgear-fixed group and 2.55 mm in the functional-fixed group. As the pre-treatment values were also similar, there was no significant intergroup treatment difference. The amount of overjet reduction in each group correlated well with the cumulative movement of both upper and lower incisors in relation to sella vertical.

Discussion

The study was a retrospective cephalometric comparison between two non extraction treatment modalities. The aim was to determine if any significant treatment changes existed between these two treatment methods. The duration of treatment for the functional-fixed group was 6 months longer than the headgear-fixed group which would be expected to be associated with linear measurements tending to be larger.¹⁷

Gianelly and coworkers¹³ found a 3.1 mm of mandibular growth per year in his Fronkel group as compared to 2.7 mm per year in the Edgewise group. In contrast, Remmer and coworkers¹⁴ in comparing the treatment changes using Activator, Fronkel and Edgewise therapy in non extraction cases concluded that mandibular length was unaltered by functional or fixed appliance.

Of interest was the initial mean overjet which was 7.92 mm in the fixed group and 8.83 mm in the functional-fixed group with no statistical significant difference. This further indicated that initial overjet did not solely dictate the choice of treatment modality but that overall skeletal discrepancy played a major role in the choice. The functional-fixed therapy lasted longer by 6 months on the average and may have affected the changes in the linear measurements.

In this study, it was shown that there were mean increases in both groups. The mean increase in mandibular length seen in the headgear-fixed group might be due to a combination of favourable forward growth of the chin as suggested by Neger²³ and extraoral traction which allows the mandible to grow downward and forward.²⁴

Comparatively, the increases in the linear measurements of the mandible were larger in the functional-fixed group. While this difference may be explained by the longer treatment duration, yet the period difference was only 6 months whereas the increase in mandibular length (Ar-Gn) was significantly different (7.58 mm in the functional-fixed and 4.33 mm in fixed).

Another striking feature was the absence of posterior rotation of the mandible in both groups. Indeed the statistically nonsignificant mean decrease in the maxillomandibular planes angle indicated an anterior rotation of the mandible. This was evident in the increase in SN pogonion in both groups which therefore had a more anteriorly positioned symphysis. The inhibition of forward growth of the maxilla was evident in the fixed group with extraoral traction³ and in the absence of any such direct restraining force, the maxilla was less affected in its growth pattern in the functional-fixed.

The correction of sagittal relationship was by a significant mean decrease in SNA in the headgear-fixed group² whereas in the functional-fixed it was due to both a mean decrease in SNA and an increase in SNB. The pre-treatment sagittal discrepancy as measured by angle ANB was greater in the functional-fixed group (6.65°) when compared to headgear-fixed (5.43°). However, as the amount of sagittal correction was similar in both groups (2.08° in functional-fixed and 1.80° in headgear-fixed), the post treatment value for ANB was not surprisingly higher in the functional-fixed (4.57°) as compared to the headgear-fixed group (3.63°). It is therefore suggested that to obtain further sagittal correction in the functional-fixed therapy, extraoral traction by headgear be applied to the maxilla to restrain its forward growth if this is desirable.

Battagel¹⁷ in her study on Fronkel and Edgewise therapy found no difference between the two groups in the increase in lower anterior face height. This was in accord with the findings of Remmer et al.¹⁴ In this study, both treatment modalities showed increases in lower anterior face height with a larger increase in functional-fixed ($p < 0.01$). These increases in lower anterior face

height occurred without any resultant backward rotation of the mandible.

There was significant incisal tipping in both groups as would be expected in non extraction therapy.^{3,23} Interestingly, while the mean decreases in upper incisal inclination were similar in both groups, there was a difference in UIE-VrI, i.e., a smaller decrease in the functional-fixed group. This was probably due to the maxilla being allowed to grow in a forward direction in the functional-fixed group as evidenced by the mean increase in A-VrI and hence affecting the UIE-VrI.

The amount of lower incisor proclination in both groups was significant with a bigger increase in the functional-fixed group. This amount of lower incisal proclination in both groups has drawn concern to the post treatment stability²⁵ and may warrant prolonged retention regime. The mean increase in the distance of lower incisal edge to sella vertical was the result of a combination of labial flaring of lower incisors and an increase in mandibular length.

The mechanism by which overjet was reduced differed in both groups. In the headgear-fixed group, it was due to significant restraint on the maxilla (no increase in A-VrI), some increase in the mandibular corpus length (Go-Gn increased by 2.35 mm) and significant incisal tipping. Comparatively in the functional-fixed group, it was the cumulative effect of a significant increase in the Go-Gn of 4.52 mm and appreciable incisal tipping especially significant lower incisal proclination.

It must be borne in mind, however, that this study involved a period of active treatment of two treatment modalities. Further study is required to ascertain the long term post treatment outcomes of patients treated by these treatment modalities in view of reported "catch up" growth in control groups when compared to groups utilising functional appliances.

Conclusions

1. There was a greater increase in mandibular length in the functional-fixed group.
2. The increase in mandibular length was not associated with a posterior rotation of the mandible in both groups.
3. The use of headgear in the fixed group resulted in inhibition of forward maxillary growth.
4. Angular measurement ANB decreased in both groups by a significant decrease in SNA in the fixed group whilst it was a combination of a

- decrease in SNA and an increase in SNB in the functional-fixed group.
5. Lower anterior face height increased more in the functional-fixed group without any resultant posterior rotation of the mandible.
 6. There was significant incisal tipping in both groups with a larger lower incisor proclination in the functional-fixed group.

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