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Efficacy of Carrier Motion Appliance in Phase-I Correction of Class Ii Malocclusion in Growing Patients Having Retro Positioned Lower Jaw – A Longitudinal Study

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KEYWORDS

angle class II, malocclusion, orthodontics, corrective

ABSTRACT:

Background: Skeletal imbalances, especially mandibular retrusion, are frequently the cause of class II malocclusions. Mandibular growth stimulation is the goal of fixed functional appliances, or FFAs. However, the rotation of the maxillary molars and the position of the mandibular incisors are frequently not precisely controlled by conventional FFAs. The Carriere Motion Appliance (CMA) was created in order to overcome these restrictions. The mandible is advanced and maxillary molar rotation is corrected by this intermaxillary Class II corrector.

Purpose: To assess the skeletal and dental improvements in developing Class II malocclusion patients in rural western Maharashtra who have had their lower jaws retropositioned using the Carriere Motion Appliance.

Material and Method: A prospective longitudinal research involving 29 developing patients between the ages of 12 and 15 was carried out. Patients with Class II malocclusion who presented to the Department of Orthodontics and Dentofacial Orthopedics at Rural Dental College, Loni, with a retropositioned lower jaw and upper molar mesiorotation, had samples taken. The CMA was used to treat the subjects for six months. Lateral cephalograms and study models from before and after therapy were assessed and contrasted.

Results: At the conclusion of phase I treatment with CMA, there were notable alterations in the molar and canine relationship, overjet, and overbite. All of the patients showed a significant rise in both the SNB and ANB angles. Furthermore, a modest distalization and distorotation of the upper molars were noted. It also showed variations in the vertical dimension.

Conclusion: In growing patients with Class II malocclusion and a retropositioned lower jaw, the CMA is efficient and successful in causing skeletal and dental alterations.

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INTRODUCTION

Dr. Sassouni[1], subdivided Class II malocclusion into 128 dentofacial Class II situations. Thus, each of these type demand different approach in order to correct them. According to McNamara[2], mandibular retrusion accounts for more than 80% of Class II malocclusions. Hence, the majority Class II malocclusions require forward positioning of the lower jaw. Additionally, distorotation of the maxillary molars is perhaps needed in certain specific cases

In the search of literature, there is a plethora of myofunctional appliances that have been introduced that are targeted towards treating the underdeveloped lower jaw in skeletal Class II cases. The appliances might be fixed or removable. Over the years, an abundance of FFAs have been introduced in the field of orthodontics such as Herbst appliance,[3] MARA, AdvancSync, Forsus, etc. These appliances are independent of patient compliance, action is continuous for 24 hours, they can be used successfully in post-adolescent patients, relative treatment duration is less, etc.

Few appliances seek to accomplish the goal of concurrently advancing the mandible and derotating the maxillary molars, despite the fact that numerous fixed functional appliances can produce advancement of a retropositioned lower jaw. According to the literature, the Carriere Motion appliance is the only one that may be able to successfully, efficiently, and simultaneously accomplish both of the aforementioned goals.

In 2004, Dr. Luis Carrière[4] created the Carriere Motion appliance (CMA). It was intended to be a non-extraction, intermaxillary Class II corrector. It is a single unit consisting of a hook on the canine pad and a ball-and-socket design on the molar pad joined by a stainless-steel rod-like structure. Because a CMA is usually administered before to the delivery of a complete fixed appliance, it can improve the overall comfort and experience of adolescents.

Although CMA has gained popularity among medical professionals in the past ten years., only few prospective studies, case reports, and a recent systematic review and metanalysis have evaluated and proven the treatment efficiency and efficacy of the Carriere motion appliance for Class II malocclusion correction in different ethnic populations.[5-8]

Therefore, an attempt has been made to assess the skeletal and dental changes caused by the Carriere motion appliance in growing patients with Class II malocclusion having a retropositioned lower jaw in a larger native population in an effort to correct the condition in a hygienic, esthetic, and compliant manner. This is because the condition involves a retropositioned mandible with a component of unfavorable maxillary molar rotation.

MATERIALS AND METHODS

Study design

This was prospective longitudinal study conducted in the Department of Orthodontics, Rural Dental College, Maharashtra, India. The Institutional Ethical Committee approval was received from the Pravara Institutes of Medical Sciences.

The sample size was calculated using OpenEpi, version 3, open-source calculator, for 95% confidence limit and power of study to 80%, an effective sample size of 29 using, simple random sampling technique, of both sexes with an age of 12-15 years was selected.

Inclusion criteria included growing individuals with skeletal/dental/ dentoskeletal Class II malocclusion having a retro-positioned mandible and upper molar mesiorotation, no prior orthodontic treatment histories, having all the records (cephalometric X-ray and study, with positive clinical VTO (Visual treatment objective), no craniofacial deformities, presence of good-quality lateral cephalograms and study models, availability of all the pre-treatment (T0) and post-treatment (T1 at CMA removal) records (study models, lateral cephalograms, intraoral and extraoral photographs)

Patients were treated using Carriere motion appliance over a mean duration of 6 months. The anterior canine pad of the CMA was bonded onto the maxillary canine and the posterior ball-and socket joint was bonded onto the maxillary first molar. Essix retainer was fabricated over the mandibular arch after banding of mandibular first molars as a source of anchorage. In the beginning, 6 oz, 1/4" Class II elastics were given followed by 8 oz, 3/16" Class II elastics. Patients are advised to wear elastics for a minimum of 18-22 hours per day and to change them after every 2 days. Patient follow-up occurred monthly during the active treatment. The

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appliance was removed when a Class I canine relationship was obtained.

The study model impressions were taken using alginate. Whereas, all cephalometric radiographs were taken under standard conditions, in centric occlusion according to the natural head position and after a usual swallow by the same technician. The magnification rate on radiographs is 1.1. All the pre-treatment study models and cephalometric findings were compared with post-treatment findings using the same parameters **(Table 1-2).** The master charts were prepared for the before and after treatment findings, and the outcomes were compared.

Statistics

The data was obtained and entered in Microsoft Excel Version 13. The data was analyzed using IBM Statistical Package for social science version 21. For continuous data, Mean and Standard Deviation was obtained. For Pre and Post evaluation of the data, Paired t test was applied.All the statistical tests were applied keeping confidence interval at 95% and ($p<0.05$) was considered to be statistically significant.

RESULTS

Table 3 and Graph 1 shows comparison between pre-treatment and post treatment evaluation of study models. It was observed that there was a statistically significant improvement in the pre and post right molar (mm), left molar (mm), right canine (mm), left canine (mm), overjet (mm) and overbite (mm) with the mean difference of 4.75mm, 5.01mm, 4.67mm, 4.81mm, 3.53mm, 3.79mm respectively. As the p value of all the study model variables evaluated pre- and post-treatment is less than 0.0001, the changes observed are extremely statistically significant.

Table 4 and Graph 2 shows molar derotation between pre and post treatment studied on the study models (in degrees). It was observed that statistically significant molar derotation was observed on both right and left side. The mean distribution for left molar rotation pre-treatment was 17.3 and post-treatment was 14.2. Whereas, for the right molar rotation pre-treatment was 19.1 and post-treatment was 15.9 respectively, with the p value <0.001

Table 5 and Graph 3 shows comparison of the pre-treatment and post treatment lateral cephalometric evaluation. It was observed that the difference in mean between the pre and post treatment values was extremely statistically significant for SNB (º), ANB (º), N per pog (mm), Y axis (º), L1-NB (º), L1-NB (mm), LAFH (mm), and PTV -U6 (mm) was -2.45(º), 2.53(º), -3.05mm, -3.02mm, -3.22mm, -2.01mm, -2.36mm and 4.60mm respectively, with the p-value <0.0001.

The (Go-Gn)-SN (º) increased by a mean of -0.89(º), which was statically significant with p value of 0.01. IMPA (º) also increased from T0- T1, the changes were statistically significant with p value of 0.052 with the mean difference of 3.68 (º). Whereas for other variables, such as SNA (º), U1-NA (º), N per pt. A (mm), U1-NA (mm), FMPA the changes were statistically non-significant with the p value of 1.000, 0.787,1.000, 0.897 and 0.119 respectively, with the mean difference of 0.00 (º), 0.24 (º), 0.00 mm, 0.05 mm and 0.65 (º) respectively. **(Table 5 and Graph 3)**

DISCUSSION

At T1, the molar relationship improved by an average 4.75 mm on right side and 5mm on left, locking molars in Class I. Recognizing that mesially rotated molars can exacerbate Class II molar relationships[9-13] and considering previous studies suggesting that CMA induces distal rotation of maxillary molars, the mean rotation of upper molars was 3.20° on right side and 3.10° on left. The observed improvements can be attributed to three factors: 1. Upper molar distalization; 2. Lower molar mesialization with mandibular advancement; 3. Distal Rotation of Upper Molars. The results align with those of Kim-Berman et al.,[5] (5.1mm), Schmid et al.[14] (3.45 ± 2.33 mm) during phase I and Zion et al.[15] molar relationship (U6-L6) within CMA group improved by 3.9mm overall. Yin et al.[7] found Class II molar relationship correction of 3.7±1.7 mm. Similar findings were found in investigations by Wilson et al.[16] (1.83 ± 2.11 mm) and Areepong et al.[6] (groups 1—skeletal Class I and 2—skeletal Class II: -1.92 mm±0.80mm and -1.67 mm±1.56 mm, correspondingly), which were less than results obtained in the current research. These studies determined that Class II correction was" largely due to distal tipping rather than translatory distal movement of maxillary molars.

In the current study, the canine relationship improved by was 4.6 mm bilaterally. These findings align with those of Yin et al.,[7] (3.5–3.7 mm) and Wilson et al.[16] (3.16 ± 1.89 mm) in patients treated with standard CMA. Conversely, our results differ from the literature where the average displacement was 2-3mm. Previous studies observed that distal movement of maxillary canines involved tipping and rotation" components rather than bodily movement in both groups.[6,9,17] This discrepancy may be ascribed to use of lighter Class II elastics, poor patient compliance, shorty model of the CMA, or other anatomical factors.

The reduction in overjet observed in this investigation can be ascribed to various factors, including distalization and distal rotation of upper molars, mesialization of lower molars, and proclination of mandibular anterior, supra-eruption of lower molars due to Class II elastics. This leads to clockwise rotation of mandible. Further supporting these findings, a study by Areepong et al.[6], Sandifer CL et al.[18], Luca et al.[19], Wilson et al.[16] and Ghozy et al.[20]

At the end of T1, SNB and ANB angle decreased significantly, these findings suggest that CMA facilitates mandibular advancement. Utilizing heavy Class II elastics (8 oz), worn nearly full-time by patients, contributed to more pronounced changes in ANB, compared to previous studies[5,19,20], as they employed lighter elastics (6 oz). This resulted in a clinically significant degree of mandibular advancement. The appliance did not significantly alter maxilla's sagittal position, as it is bonded to canine while the maxillary incisors remain free. Therefore, the SNA angle and N per to pt. A remained relatively unchanged. The minimal change in the SNA angle aligns with Proffit's assertion that maxillary effects, though minor, typically accompany mandibular modifications. Soft tissue elasticity creates reactive force against maxilla when mandible is held forward, which might result in stability at pre-treatment levels or small reduction in SNA angle. Tulloch et al.[21] have offered similar explanations.

The present study observed changes in the vertical dimensions as well and were similar to that found in the previous literature [5,6,19]. Research by Yin et al.,[7] concluded that LAFH increase with the CMA was less than that seen with Class II elastics and fixed appliances" (5.0mm). Zion et al.[15] identified molar extrusion as a contributing factor to vertical skeletal alterations leading to clockwise rotation of the occlusal plane. This etiology was also confirmed by Ghozy et al.[20] and A. Clermont,[22]. Although vertical changes generally appliances induce were statistically significant skeletal changes, their clinical impact remains minor. This notion was supported by Taylor et al.[23], Koretsi et al. and Zymperdikas et al.[24].

Although appreciable changes were observed with the increased proclination of lower incisors by an average of 3 degrees despite of using Essix retainers. The results were in alignment with Schmid et al.[14] (2.94 ± 2.52°) and Wilson et al.[16] (2.65 ± 3.01°). Increased proclination was observed by Kim-Berman et al.,[5] (4.98°), Fouda et al.[25] (5.38°±4.08°) and Areepong et al.,[6] (3.5° and 4.06° in groups 1 and 2, respectively) as compared to the present research, may result from anchoring loss and the use of bulky Class II elastics. According, to this research, using Class II elastics led to lesser incisor proclination. They also indicate that a more permanent and efficient retention technique would be required to reduce the dentoalveolar effects of Class II elastics.

The present study also demonstrated average 4 mm reduction in distance between PTV and upper

molar's distal surface pre- and post-treatment. This was primarily attributed to utilizing Class II elastics. However, adjustment of molar relationship was accomplished in large part by upper molar derotation, as previously established in the literature. Our findings were in line with researches by Zion et al.[15] (2.3mm) and Ghozy et al.[20] (2.2mm), where Force 2 elastics (8oz) had been employed after Force 1 elastics (6oz) for a month. Lesser distalization was observed by Schmid et al.[14] 1.56±1.79 mm), Luca et al.[19] (1.7 mm) probably due to the use of lighter elastics.

In a nutshell, the Carriere Motion Appliance is a compact and cosy appliance having a "sagittal first approach" that effectively and efficiently corrects skeletal/ dental/ dentoskeletal Class II malocclusion with shorter treatment duration through a combination of both desirable and undesirable effects. Key benefits include mandibular advancement, maxillary molar derotation and distalization, and lower molar extrusion in individuals with a horizontal growth pattern—changes that are clinically significant. However, potential drawbacks include increased lower incisor proclination, lower molar mesialization, and increased vertical dimensions, particularly in patients with an average to vertical growth pattern. The extent of these effects may vary among individuals.

CONCLUSIONS

1. The CMA is efficient and effective in producing desirable changes in growing patients with Class II malocclusion having a retropositioned lower jaw

2. When assessed on the research models, the current study showed notable alterations in the canine and molar relations in all three dimensions at the conclusion of phase I therapy with the Carriere motion device. There were noticeable alterations in overbite and overjet. Further, upper molar distorotation was also observed.

3. Cephalometric changes with noticeable increase in SNB angle, ANB angle, lower incisor proclination and LAFH in all the patients. Additionally, upper molar distalization was also observed. This indicated that Carriere motion appliance was able to bring skeletal changes, leading to improvement in Class II facial profile by bringing the lower jaw forward and also rotating mandible in clockwise direction.

4.There was a slight to absolutely no effect on the maxilla, as upper incisors were free of any appliance attachment.

LIMITATIONS OF THE PRESENT STUDY

1. Accountability, accessibility and affordability of the CMA needs further strengthening in distribution networking and price ranging, although it is recyclable and reusable.

2. Short observation time period.

3. Stability of the results brought about by the CMA depends upon the completion of entire orthodontic mechanotherapy.

SCOPE OF THE PRESENT STUDY

1.Studies can be planned on larger sample size for longer time period.

2.More comparative studies between CMA and the control group containing other FFAs can be planned.

3.Future studies on effect of CMA on envelope of function and envelope of motion using electromyography, video photogrammetry, and other 3D/4D techniques can be undertaken.

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Competing interests

None

Ethics approval

The study was approved by Pravara Institutes of Medical Sciences. Registration number – PIMS/RDC/IEC/UG-PG/10-2023

Data availability statement

Data available within the article or its supplementary materials

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Table 1: Study model parameters

Variables	*Definitions*
Molar relationship	The linear distance measured from the mesiobuccal cusp tip of the upper first permanent molar to the buccal groove of the lower first permanent molar.
Canine relationship	The linear distance measured between the cusp tip of upper canine to the cusp tip of lower canine.
Overjet	The linear horizontal distance measured from incisal edge of most proclined upper incisor to the incisal edge of lower incisor.
Overbite	The vertical overlap measured from the incisal edge of the upper incisor to the incisal edge of the lower incisor.
U6 derotation	Assessed using Henry's angle, determined angle formed by a line passing across molar's buccal cusps and median raphe.

Table 2. Cephalometric parameters

Variables	*Definitions*
SNA	The angle between the SN plane and NA line
SNB	The angle between the SN plane and NB line
ANB	The angle between NA and NB lines
FMPA	The angle between the mandibular plane and the Frankfurt plane
IMPA	The angle between the mandibular plane and the axis of the inferior anterior incisor
Y-axis	The angle Frankfort plane and S-Gn line
Go-Gn to SN (Mandibular plane angle)	The angle between the mandibular plane (Gonion-Gnathion) and the Frankfurt plane
U1-NA $(^0)$	The angle between long axis of the maxillary anterior incisor and NA line
L1-NB $(^0)$	The angle between long axis of the mandibular anterior incisor and NB line
N per to pt.A (mm)	The linear distance between Nasion perpendicular to point A
N per to pog (mm)	The linear distance between Nasion perpendicular to pogonion
U1-NA (mm)	The linear distance between long axis of the maxillary anterior incisor and NA line
L1-NB (mm)	The linear distance between long axis of the mandibular anterior incisor and NB line
Low anterior facial height LAFH (ANS-Me)	Distance between anterior nasal spine and menton
PTV-6	Distance between the maxillary first molar and pterygovertical line

Table 3: Statistical difference of study models parameters between T0 and T1

	T0	**T1**		**t**	**p Value**

	Mean	Std. Deviation	Mean	Std. Deviation	**Mean Difference**		
Right molar (mm)	4.7069	1.05659	-.0517	.96681	4.75862	17.893	0.000
Left molar (mm)	5.0000	.79057	-.0172	1.02193	5.01724	20.912	0.000
Right canine (mm)	3.3966	1.27741	-1.2759	.89229	4.67241	16.148	0.000
Left canine (mm)	3.3966	1.18306	-1.4138	.88710	4.81034	17.518	0.000
Overjet (mm)	7.5690	1.46217	4.0345	.63991	3.53448	11.925	0.000
Overbite (mm)	7.7931	.77364	4.0000	.50000	3.79310	22.175	0.000

Table 4: Statistical difference of molar rotation (in degrees) between T0 and T1

	T0		**T1**		**Mean Difference**	**t**	**p Value**
	Mean	Std. Deviation	Mean	Std. Deviation			
Right molar rotation	19.1	2.76	15.9	2.49	3.5		<.001
Left molar rotation	17.3	2.87	14.2	2.53	3.1		<.001

Table 5: Statistical difference of the cephalometric parameters between T0 and T1

	T0		**T1**		**Mean Difference**	**t**	**p Value**
	Mean	Std. Deviation	Mean	Std. Deviation			
SNA (º)	80.5690	.95173	80.5690	.95173	0.00000	0.000	1.000
SNB (º)	75.5000	.92582	77.9655	.71877	-2.46552	-11.328	0.000
ANB (º)	5.2414	.84114	2.7069	.61987	2.53448	13.063	0.000
N per pt. A (mm)	-0.3621	1.34228	-0.3621	1.34228	0.00000	0.000	1.000

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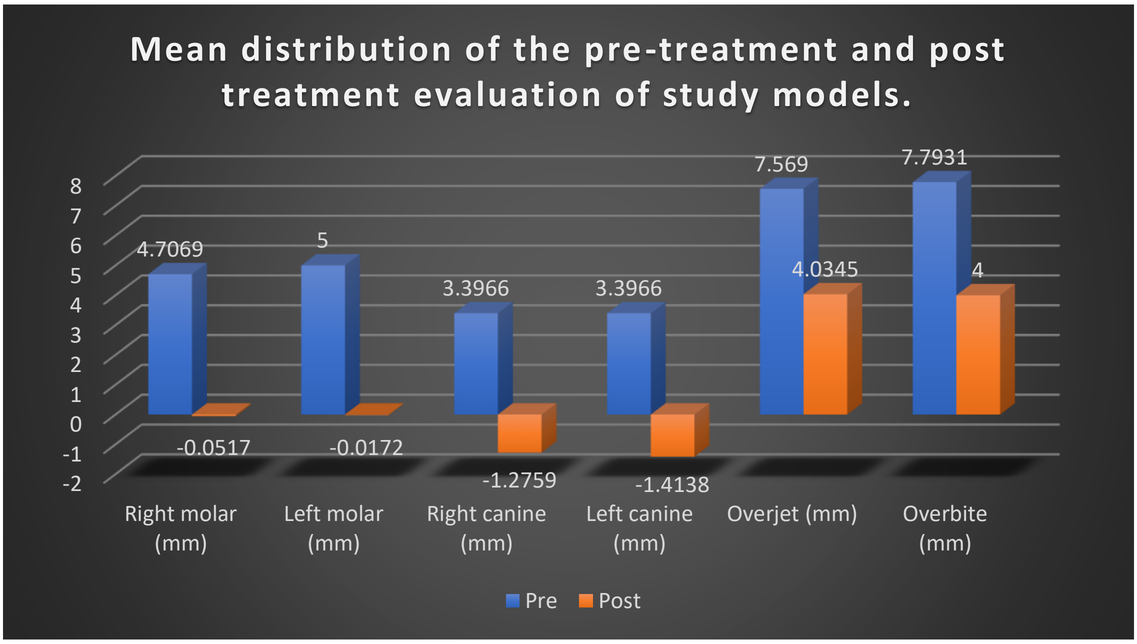
N per pog (mm)	-8.7414	.87240	-5.6897	0.45146	-3.05172	-16.730	0.000
FMPA (º)	22.6207	1.68849	23.2759	1.45520	-.65517	-1.583	0.119
Y axis (º)	57.6034	1.26335	58.5517	1.12078	-.94828	-3.024	0.004
(Go-Gn)-SN (º)	28.0690	1.34778	28.9655	1.19471	-.89655	-2.681	0.010
U1-NA (º)	30.0345	3.26489	29.7931	3.49110	0.24138	0.272	0.787
L1-NB (º)	26.3966	1.75956	29.6207	1.89292	-3.22414	-6.718	0.000
IMPA (º)	102.5862	7.43792	106.2759	7.33337	-3.68966	-1.902	0.052
U1-NA (mm)	6.6552	1.49465	6.7069	1.53830	-0.05172	-0.130	0.897
L1-NB (mm)	5.9310	1.55681	7.9483	1.71831	-2.01724	-4.685	0.000
LAFH (mm)	56.3448	2.08354	58.7069	2.32808	-2.36207	-4.071	0.000
PTV -U6 (mm)	14.9655	1.60874	10.3621	1.80226	4.60345	10.262	0.000

Graph 1: Mean distribution of the T0 and T1 evaluation of study models



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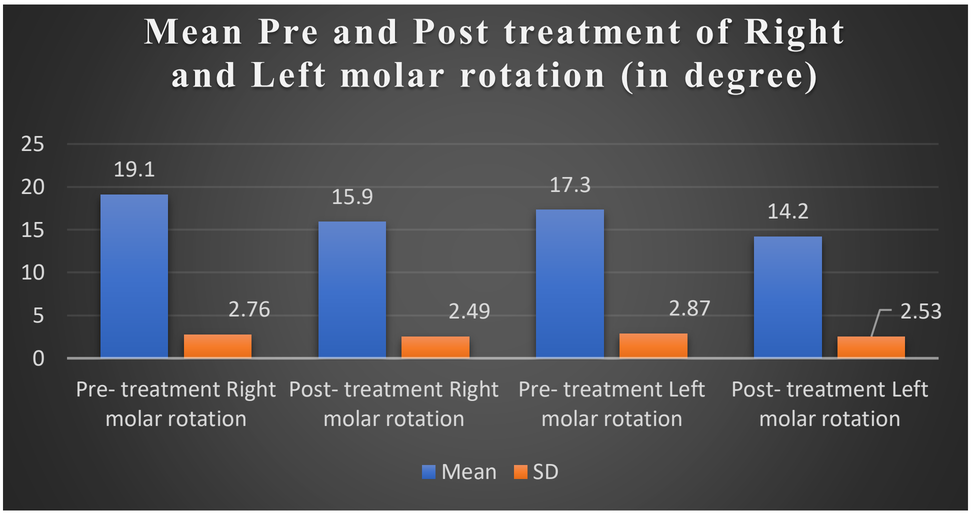
Graph 2: Mean distribution of the T0 and T1 right and left molar rotation



Graph 3: Mean distribution of the T0 and T1 Lateral cephalometric evaluation