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The Evaluation of the Efficacy of Quad Helix VS. Non-Helical Appliance in Growing Patients Having Transverse Maxillary Discrepancy: A Randomized Clinical Trial

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Introduction:

Most of the complex malocclusions which are skeletal in origin have three dimensional defects in common.The constricted maxillary arch locks the mandible resulting in the functional retrognathism or retrusion of the mandible[1].Transverse malocclusion is seen in 30% of the Indian population which has got narrow maxillary arch along with posterior crossbite, increased overjet and overbite, proclination of maxillary incisors, deep palatal vault, increased overjet and overbite, V shape arch, convex profile, narrow arch, incompetent lips[2-3].
In order to correct the constriction in the maxillary arch, various modes of palatal expansion have been introduced which can be classified as either slow maxillary expansion or rapid maxillary expansion. The mode of assessment of this palatal expansion varies from Pont's analysis to PTID protocol (posterior transverse inter-arch discrepancy)[4].

The Quad Helix appliance, which is typically made of circular stainless- steel wire that is the most commonly employed appliance for posterior crossbite correction in mixed dentition period. It has 4 loops with increased flexibility. When activated, the quad helix appliance produces orthopaedic and orthodontic changes in the maxillary arch. Even though it works well, it has certain drawbacks such as additional challenges. At present, inexperienced parents perform intraoral adjustments; for which they must tie

floss to the adjustment wrench to make recovery easier in the event that the patient swallows it[5].

To overcome these drawbacks, Dr. Gerald W. Spencer introduced the concept of "The Non-Helical Appliance: An Alternative to the Quad Helix"[6]. He proposed the fabrication of an appliance similar to quad helix but without the helices using 0.036" round beta titanium wire.The lateral expansion arms of the appliance are adapted to the lingual aspects of the dentition. The palatal portion is bent over the lateral arms and then rounded anteriorly to fit the shape of the arch, just lingual to the anterior teeth. A V-shaped arch can easily be "fan expanded" to correct any mesial rotation of the upper first molars. The non-helix appliance can be adjusted to produce a distal force on the contralateral molar, or even bilateral expansion and distalization.(Figure 1)

Figure 1. Non-helical appliance

As the concept of non-helical appliance as an alternative for the conventional quad helix is fairly recent, the functioning of the appliance hasn't been verified and there are no literatures which compare the working of the new appliance with the conventional appliances. Hence, the purpose of this study was to evaluate and compare the efficacy of the conventional helical (quad helix) and the non-helical palatal expanders in growing patients having transverse maxillary discrepancy on study models and occlusal radiographs as phase 1 treatment.

Material and methods

This experimental study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics of Rural Dental College, Loni during the period of May 2022 to October 2024, with record collected within the department from May 2022 to December 2022 for both quad helix and Non-helical expander. A written approval was obtained from the Institutional Ethical Committeeon 29/04/2022 (No: PIMS/DR/RDC/2022/520). Inclusion criteria for this study included patients with early/intermediate/late mixed dentition, patients in CVMI stage 1 – 3, patients with transverse maxillary discrepancy expressing as unilateral/bilateral skeletal posterior

crossbite, patients whose parents/guardians willing to give written and informed consent to this study. Exclusion criteria includedpatients who have undergone previous active orthodontictreatment and syndromic or craniofacial anomaly or hormonal disorders.

Sample size was calculated using A.P Kulkarni excel sheet software for 90% confidence limit and power of study to 80%, resulting in sample size of 30. Samples will be collected from the patients of age group between 7-12 years of both sexes, who are in their early mixed dentition, who report to the Department of Orthodontics and Dentofacial Orthopedics, Rural Dental College, Loni. Each eligible patient who have opted to undergo the treatment will be subjected to random lottery method and divided into 2 group 1. QH (Quad Helix) group i.e the QH group and 2. NHA (Non-Helical Appliance) group i.e the experimental group. Study models and occlusal radiographs of all the 30 patients were collected at both base Preand Post completion of Phase 1 therapy.

Variable assessment on study models:

Sr. No	**Variable to be studied**	
1.	Inter-canine Width	Inter-canine width is measured from tips of the right and left canines.
2.	Inter-premolar Width	Pont's Index is used. Inter-premolar width is measured.
3.	Inter- molar Width	Pont's Index is used. Intermolar width is measured.
4.	Decrowding of anteriors	Total tooth material and arch perimeter discrepancy is measured.
5.	Proclination by direct method	A set square is used so that the edge of the set square is perpendicular to the floor and touches the labial surface of the most proclined teeth. The proclination is measured from the deepest point in the sulcus to the edge of the set square.
6.	Spacing	Spacing is measured with a transparent scale between all the teeth mesial to first molar.

Variable assessment on occlusal radiograph:

Sr. No	Variable to be studied	
1.	Inter-canine width	Inter-canine width is measured from tips of the right and left canines.
2.	Inter-premolar width	Inter-premolar width is measured from tips of the right and left first premolar.
3.	Inter-molar width	Inter-molar width is measured from tips of the right and left first molar.
4.	Mid-palatine suture	Distance between the medial surfaces of the right and left palatine process of maxilla

Statistical analysis:

The data was collected and recorded into Microsoft excel spreadsheet. The Windows program SPSS version 20 (IBM SPSS statistics Inc., Chicago, Illinois, USA) was used for the analysis. The results of the study were subjected to statistical analysis for the tests. Computation of percentages, means and standard deviations was included under descriptive statistics. The significance level of all statistical analyses set at 1. $p > 0.05$ - Not statistically significant 2. $p \leq 0.05$ - Statistically significant 3. $p \leq 0.01$ - Highly statistically significant 4. $p \leq 0.0001$ - Extremely statistically significant

Results:

30 patients were included in this study with no significant age and gender difference. There is a significant increase in the inter-canine, inter-premolar and inter-molar widths after the treatment in the QH group. Statistically, the increase in all the 3 widths wereextremely significant.The pre and post treatment mean difference values for de-crowding of anteriors, proclination by direct method and for the spacing, all the 3 values were statistically significant. (Table 1)

There was a significant increase in the inter-canine, inter-premolar and inter-molar widths after the treatment seen on occlusal radiograph too. Statistically, the increase in all the 3 widths were extremely significant. (Table 2)

The comparison between pre and post treatment mean difference values of the change in the study models parameters for the NHA group that have been given the Non-helical appliance.There is a significant increase in the inter-canine, inter-premolar and inter-molar widths after the treatment. Statistically, the increase in all the 3 widths were extremely significant. The pre and post treatment mean difference values for de crowding of anteriors, proclination by direct method and spacing, all the 3 values were statistically significant.(Table 3)

There is a significant increase in the inter-canine, inter-premolar and inter-molar widths after the treatment group that have been given the Non-helical appliance. The pre and post treatment mean difference values of the inter-canine and inter-premolar widths was 1.760 ± 0.7249 and 1.613 ± 0.5668. Similarly, the pre and post treatment mean difference values of intermolar width was 5.267 ± 0.4952. Statistically, the increase in all the 3 widths were extremely significant. (Table 4)

Thecomparative mean difference between pre and post treatment values of each group on maxillary occlusal radiograph, i.e the Quad Helix and the Non -helical appliance groups. Statistically no significant difference was found when the two groups were compared with each other but Quad helix group showed greater change in the inter-canine and inter-molar width compared to the NHA group. (Table 5)

Themean difference between pre and post treatment values of each group, i.e the Quad Helix and the Non -helical appliance groups. Statistically no significant difference was found when the two groups were compared with each other but Quad helix group showed greater change in the inter-canine and inter-premolar width compared to the NHA group. (Table 6)

Discussion

This study was done to check the efficacy of the two appliances in the correction of transverse discrepancy, a total of 30 subjects were equally split into two groups; a QH group (15 patients) in which the quad helix was given and in NHA group (15 patients) that received the Non-helical palatal expander for transverse correction. over a period of six months and result were discussed on the basis of (0, 6) months protocol. The subjects were included in the study by assessing the CVMI stage (Stage 1-3) and subjects who were yet in growing period having mixed dentition were included in the study with no gender discrimination was done while including the subjects in the study and the subjects with either gender were selected to get more heterogenous group samples for better outcome for the population. The variables used in the study can be divided into 2 categories: 1.Study model 2. Occlusal radiograph

1. Study model analysis:

a. Changes in the arch width: The results of this study show that there is a highly statistically significant (P<0.0001) increase in inter-canine width with the mean pre-treatment value of29.4 and that of post-treatment being 32.8 seen for the sample group of Quad Helix (Table 5). Similarly, a significant (P<0.0001) increase was also seen in the sample group of the NHA where the mean inter-canine width initially was 29.1 which increase to 31.8 post-treatment.

There is definite increase in the transverse dimension with both the appliances however, the statistical analysis of comparison of pre- and post-treatment values indicates a very significant difference in the extent of expansion at the canine region.Bell and Lee Compte[7]in 1982 demonstrated that the quad-helix appliance has notable improvement in the width of the maxillary inter-canine arch. Comparable results were found for inter-canine dimensions changes, which showed an average increase of 4.1 + 0.5 mm, or a transverse expansion amount of 14%. This level of expansion was comparable to the arch width increases reported by Berlocher et. al.[8]employing rapid palatal expansion procedures in the deciduous and early mixed dentitions.

The statistical analysis of the inter-premolar width showed significant (P<0.0001) changes in the pre- and post-treatment values, in both, the quad helix and the non-helical palatal expander sample groups. The mean difference of 2.320 + 0.2426 was seen in the NHA group while that of 2.5 + 0.4551 was seen in the quad helix sample group. It was noted that the variation in the amount of changes brought about by both the appliances were not very significant.

Al-Obaidi HA, Al-Mallah MR. (2012)[9] in their study stated that there was a significant difference regarding the rate of maxillary inter1st premolars width change, the rate ofmaxillary inter-2nd premolars width change and the rate of maxillary inter-1st molars width change, between the Hyrax expander and the other two expanders. When examining arch width changes, we observed that the Hyrax appliance increased the inter-premolar width at a range of 1.41mm, while the Quad-Helix and the W-Arch appliances resulted in an increase at a rate of 0.93mm and 0.92mm respectively. The results of the Quad-Helix expander of the study were close to a study by Bjerklin[10], who saw an increase of 1.3 mm in the 1st premolar region; and were less than other studies which reported an increase of inter-premolar width range from 3.1mm to 5.8mm.

The statistical analysis shows that there is a statistically significant (P<0.0001) increase in inter-molar width with the pre-treatment mean value of both control and NHA group. The comparison of values of the two appliances shows that, the extent of expansion of the quad helix appliance at the molar region is significantly more that by the NHA.

Krister Bjerklin[11] in his study stated that there was a tendency toward more transverse expansion between the maxillary molars in the helix group compared to the expansion plate group. This might be because the children in the quad-helix appliance group experienced more buccal tilting of their maxillary first permanent molars than did the children in the removable expansion plate group.Similarly, V.E. Donohue et. Al[12], in his study proposed that compared to the NiTi expander, the quad helix provided a far

more regulated differential expansion between the first molars and the first premolars. According to him, this varied controlled force application on the molar and premolar, is one of the most note-worthy advantage of the quad helix appliance. Same results were shown by Erdinç, Ugur and Erbay (1999)[13]and B Boyesen et al. (1992)[14]

Gidwani, et al (2018)[15]studied the QH appliance's efficacy to expand arches compared to two other slow maxillary expanding appliances (EP with jack screw and NiTi tandem loop) in this systematic review. The expansion that the QH appliancewas less.

b. Changes in the arch perimeter: The quad helix as well as the non-helical appliance, both showed similar results in the increase in the arch length that led to the unravelling of crowding. While both the appliance demonstrated mild increase in the arch length, the difference between the two appliances isn't significant.Subsequently, in this study, the quad helix appliance expansion led to minor changes in the values of proclination with a pre- and post -treatment mean values being 6 and 5.7 respectively. Subsequently, there wasn't any significant changes in the proclination seen post NHA treatment as well where the pre- and post-treatment mean values were 6 and 5.9 respectively.

Yoshiki Kobayashi, Isao Shundo and Toshiya Endo (2012)[16]studied the treatment effects of quad-helix on the eruption pattern of maxillary second molars. They concluded that N The quad-helix treatment in the mixed-dentition patients with maxillary incisor crowding gives rise to spontaneous distal tipping and impeded vertical eruption of the maxillary second molars with distalization and impeded extrusion of the maxillary first molars.

Hawa Shoaib et al, 2017[17]claimed that following expansion, the maxillary arch perimeter grew noticeably, averaging 6.9 mm for 9.1 mm of inter-molar width and 0.7 mm for each 1 mm of inter-molar expansion. The posterior region of the maxilla experienced a larger outcome as a result of expansion than the anterior region according to Ladner, P.T., Z.F. Muhl, 1995[18]. Nearly similar results were found by Akkaya (1999)[19] was 0.7: 1mm. While Berlocher et al (1980)[20] reported 1mm increase for every 1mm of inter molar expansion.

2. Occlusal radiograph analysis:

Mariana Boessio Vizzotto. et. al. (2003)[21]carried out a study measure the transversal widths on the occlusal radiograph. According to the study, mean intermolar widths after a one-month interval with no retention were significantly higher than mean pretreatment values and shorter than in post-active treatment and post-retention values). For the inter-canine region, the approximate ratio of the sutural opening was 6:1, and for the intermolar area, it was 10:1.

According to Storey et al.'s 1973 report, when sutural integrity is preserved during maxillary remodelling, the mid-palatal suture opens, incomparison to rapid suture expansion, SME results in less traumatic disruption, a stronger reparatory reaction, and improved sutural stability. Bell et al. (1982) reported that compared to the disruptive character of rapidly expanding maxillary segments, the pace of midpalatal suture separation by gradual expansion systems appears to provide a more physiologically bearable response by the sutural elements.
According to Moyers et al.'s 1974 study slow expansion techniques raise the proportion of orthodontic motions because the suture elements' tensile strength is maintained.

Kumar et al. (2016)[22] conducted a FEM study comparing the quad helix with a NiTi palatal expander with concluded that both groups had transverse opening of the mid-palatal suture, with the highest degree of dislocation shown in the posterior region with a large magnitude in the quad-helix model. The groups did not significantly differ in displacement, and the anterior opening of the mid-palatal suture was same in both. All of the mid-palatal suture sites moved forward in the sagittal plane in both models, gradually decreasing from the anterior to the posterior regions. The mid-palatal suture points moved lower in both types in a vertical manner.

Hence, the study concluded that -1. The Quad Helix is more efficacious than the Non-Helical Appliance group, in patients having Transverse Maxillary Expansion as it shows greater amount of expansion in the inter-canine widths and inter-molar width on the study models as well as the occlusal radiograph. 2.The Quad Helix and the Non-Helical appliance both showed similar amount of expansion in the inter-premolar area on the study models. On the maxillary occlusal radiograph, the amount of expansion in the inter-premolar area was more with the QHA than the NHA. 3. The changes in the arch perimeter showed similar results in both Quad Helix appliance and the Non-Helical appliance.

In summary, while this study effectively compares the expansion brought about by the two appliance, further research involving a larger sample size for a longer study duration is required to study the overall efficacy of the two appliances in all the 3 phases of orthodontic treatment

Limitations of the study:

The study was carried out without gender discrimination.However, in females the mid palatal suture can be fused earlier than expected. Hence, the effective expansion in the two genders may vary.

Another limitation was that, the sample size was considerably less. The study would have been more authentic with a much larger study group

Authors contribution

All the authors have contributed equally in conceiving the idea, data collection, analysing the data and manuscript preparation

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent. The patient has given his/her consent for his/her images and other clinical information to be reported in the journal. And the patient understands that their names and initials willnot be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Statement of informed consent

Necessary ethical clearances and informed consent was received and obtained respectively before initiating the study from all participants.

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Nil

Conflicts of interest

There are no conflicts of interest.

Ethical certificate

A written approval was obtained from the Institutional Ethical Committee, Pravara Institute of Medical Sciences on 29/04/2022 (No: PIMS/DR/RDC/2022/520


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Tables:

Variables	Mean difference	SD difference	P value
Inter-canine width (mm)	3.373	0.4949	<0.0001

Inter-Premolar width (mm)	2.500	0.4551	<0.0001
Inter-molar width (mm)	4.420	0.2426	<0.0001
Decrowding of anteriors	-0.5	0.3273	<0.0001
Proclination by direct method	-0.3333	0.4082	0.0069
Spacing	0.5667	0.4577	0.0003

Table 1: Statistical Analysis of Evaluation of study models for Pre- and Post-Treatment of QH group (paired t-test)

	Mean difference	**SD difference**	**P value**
Intercanine width (mm)	2.813	0.4155	<0.0001
Inter Premolar width (mm)	1.980	0.2274	<0.0001
Intermolar width (mm)	5.180	0.1821	<0.0001

Table 2:Statistical Analysis of Evaluation of occlusal radiograph for Pre and Post-Treatment of QH group. (paired t-test)

	Mean difference	**SD difference**	**P value**
Intercanine width (mm)	2.767	0.4370	<0.0001

Inter Premolar width (mm)	2.320	0.2426	<0.0001
Intermolar width (mm)	3.893	0.2685	<0.0001
Decrowding Of Anteriors	-0.3333	0.3086	0.0009
Proclination by direct method	-0.1333	0.2289	0.0406
Spacing	0.3333	0.3086	0.0009

Table 3: Statistical Analysis of Evaluation of study models for Pre- and Post-Treatment of NHA group (paired t-test)

	Mean difference	**SD difference**	**P value**
Intercanine width (mm)	1.760	0.7249	<0.0001
Inter Premolar width (mm)	1.613	0.5668	<0.0001
Intermolar width (mm)	5.267	0.4952	<0.0001

Table 4: Statistical Analysis of Evaluation of occlusal radiograph for Pre and Post-Treatment of NHA group (paired t-test)

	Mean difference	SD difference	P Value
Inter-canine width (mm)	3.373	0.4949	0.0014
	2.767	0.4370	
Inter-Premolar width (mm)	2.500	0.4551	0.1873
	2.320	0.2426	
Inter-molar width (mm)	4.420	0.2426	<0.0001
	3.893	0.2685	
De-crowding of Anteriors	-0.5	0.3273	0.1624
	-0.3333	0.3086	
Proclination by direct method	-0.3333	0.4082	0.1091
	-0.1333	0.2289	
Spacing	0.5667	0.4577	0.1128
	0.333	0.3086	

Table 5: Statistical Analysis of comparison of study models values for Pre and Post-Treatment of Control versus NHA group (Unpaired t-test)

	Mean difference	SD difference	P Value
Inter-canine width (mm)	2.813	0.4155	<0.0001
	1.760	0.7249	
Inter-Premolar width (mm)	1.980	0.2274	0.0275
	1,613	0.5668	
Inter-molar width (mm)	5.180	0.1821	0.5298
	5.267	0.4952	

Table 6: Statistical Analysis of comparison of occlusal radiograph for Pre- and Post-Treatment of Control versus NHA group (Upaired t-test).