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ORIGINAL ARTICLE

Nonsurgical maxillary expansion in adults: report on clinical cases using the Hyrax expander

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ABSTRACT

BACKGROUND: Maxillary expansion in adults is object of intense controversy and is still considered an unreliable procedure within the orthodontic community. Therefore, the surgically assisted rapid maxillary expansion is still considered the elective treatment nowadays. The aim of this study is to evaluate the efficacy of a nonsurgical maxillary expansion treatment in adult patients with unilateral or bilateral crossbites and to assess the occurrence of related complications, such as pain and tissue swelling, tipping of the posterior teeth and gingival recessions.

METHODS: Maxillary expansion using a Hyrax appliance on the upper first premolars and first molars was performed in 29 patients ranged between 18 and 32 years, mean age of 22±4 years. The sample included 13 patients with unilateral crossbite and 16 with bilateral crossbite. The statistical analysis was carried out using the SPSS Statistics version 23.0. An analysis of the paired data obtained on dental casts before and after treatment was performed using the Student's *t*-test.

RESULTS: The posterior crossbite was fully corrected in all patients. The procedure was well tolerated, and pain, swelling or discomfort was not significant. Statistically significant differences were found between the interdental widths for all pairs, with a $P<0.001$ for all of them, except in the measurements of canines, in which $P=0.001$. Measurements of clinical crown height at the beginning (T_0) and at the end (T_1) of treatment were performed for the same teeth. An increase of the clinical crown height between 0.14 and 0.44 mm was found for premolars and molars.

CONCLUSIONS: The results indicate that nonsurgical maxillary expansion in adult patients is an efficient method for correcting transverse deficiency in the maxillary arch. Similarly, the level of complications during treatment was not clinically significant, thus this procedure may be considered a safe treatment.

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KEY WORDS: Palatal expansion technique - Gingival recession - Adult.

Maxillary expansion was first proposed by Angell in 1860, using a device to support the premolars.[1] Upon activation, the device increased the width of the palate, creating an interincisal diastema together with many other dental and skeletal effects due to the maxillary expansion treatment.[2, 3] In 1961, Haas presented a new maxillary expansion apparatus he had designed;[4] this device was later modified by Biederman.[5] In 1954, Subtenly *et al.* showed that the repositioning of maxillary fragments was slower in adult patients, attributing this to the closure of the palatine suture. The zygomatic and pterygomaxillary regions were subsequently found to exhibit even greater resistance than the palatine suture.[6] It was therefore concluded that osteotomy could be used in adult patients to reduce or eliminate these resistant regions, helping to facilitate maxillary expansion. Although a surgical technique for opening the median palatine suture was first

described in 1938,[7] it was not until the middle of the 20th century that the technique was further developed with the help of improved infection control protocols, thus a wide range of authors soon proposed different techniques based on osteotomies at various different levels.[8-12] However, many complications can arise from different surgeries at the dental, skeletal, mucogingival, and muscular levels, as well as complications caused by the surgical procedures involved. In more recent years, several researchers have published studies on nonsurgical maxillary expansion,[13-19] providing another possible alternative to correct a constricted upper arch. The most frequently observed side effects at a general level involve only light discomfort,[13, 14] with only one of the studies finding some patients to have experienced pain, edema or palatine lesions, although these complications did not prevent full treatment.[14] At the dental level, gingival recession was the most commonly observed adverse effect.[15-17] The literature has shown that when maxillary expansion is carried out on adult patients, the increase in basal bone is less than that of children, which is compensated by greater buccal inclination of the maxillary premolars and molars[17, 18] In addition, several studies indicate that increased buccal tooth inclination may trigger gingival recession,[20-23] although not all of the studies found a strong correlation.[24-26] Therefore, buccal inclinations of the posterior teeth may present a limiting factor for a maxillary expansion treatment without the use of surgery in adult patients.

The aim of this study is to analyze the expansion that occurred in 29 adult patients who have undergone an orthodontic treatment that included a maxillary expansion. Measurements of the crown height of molars and premolars were also evaluated in order to assess the buccal attachment loss and the potential occurrence of gingival recession.

Materials and methods

Patient selection was carried out in two orthodontic clinics (JML and JCA) between 2003 and 2014. The inclusion criteria were:

- patients with completed growth of 18 years or older at the beginning of the treatment;
- complete records before and after orthodontic treatment available;
- previous presence of transverse maxillary deficiency in which the maxillary cusps of at least two premolars and/or maxillary molars occluded on the central fossa of the antagonist's teeth;
- need of maxillary expansion for the correction of their malocclusion;
- willingness to collaborate in the present study in which the analyzed data consisted in dental casts taken at the beginning and at end of the orthodontic treatment.

Patients with congenital anomalies were excluded from the study.

This retrospective study was conducted with the approval of the Coordinating Ethics Committee of Biomedical Research of Andalusia, University Hospitals, Protocol number 001, Date of approval 9/8/2016. All the patients signed a consent form to be included in the study. The sample consisted of 29 patients, 14 women and 15 men, with a mean age of 22±4.25 years; ranged between 18 and 32 years at the beginning of treatment. Specifically, the mean age of the 14 women included in the study was 23.14±4.91 years, whereas the mean age of the 15 men was 21.94±3.35 years. The patients in the study included 13 with unilateral crossbite and 16 patients with bilateral crossbite.

The maxillary expansion was performed using Hyrax expander with a central screw of 11 mm (GAC International, Dentsply, Islandia, NY, USA) soldered to bands on the upper first premolars and first molars. The expanders were cemented with glass ionomer cement (Ketac Cem®, 3M ESPE, Seefeld, Germany). Once the appliance was cemented, the screw activation began on the same day. Family members of the patients were taught how to activate the expansion screw a quarter-turn every two days (0.25 mm/day). The average duration of the expansion was 50±6 days. Maxillary expansion was performed until complete correction of posterior crossbite in all cases. However, the overcorrection was carried out to a greater or lesser degree, depending on the individual patient factors including age, level of expansion achieved and risk of side effects. Once the transversal com-

pression was corrected, the expansion screw was sealed using a 0.012" stainless steel orthodontic wire in order to use the appliance as fixed retainer. After the expansion was completed and the screw was sealed, the appliance was kept in place between 6 and 9 months, with an average time of 30 weeks. The average length of the orthodontic treatment including both the expansion phase and posterior treatment with multibrackets fixed appliances was 2.63±0.73 years. The brackets used for orthodontic treatment were self-ligating metal brackets (Smart Clip®; 3M Unitek Oral Care) with a posterior torque prescription of 0º for upper premolars and molars.[27]

Dental casts of the 29 patients were taken at the beginning of the expansion treatment (T_0) and at the end of the orthodontic treatment (T_1).

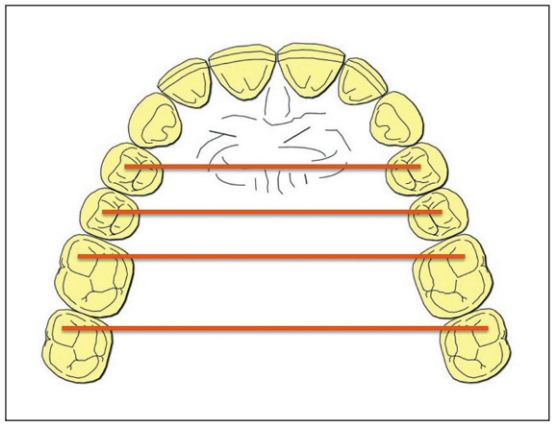

Figure 1.—Buccal distances measurements.

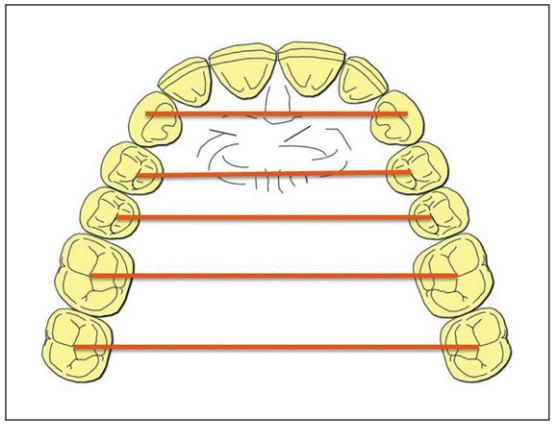

Figure 2.—Occlusal distances measurements.

If gingival inflammation was present at the end of the treatment, the final dental casts were taken between 12 and 14 days following completion of treatment, after the gingival inflammation healed, so as to avoid inaccurate measurements. Two types of measurements were taken using the dental casts: dental arch width and the clinical crown height of canines, premolars and molars, excluding the third molars. Maxillary arch width of the canines was measured using the canine cusps as reference. For premolars and molars, measurements were taken using three points of reference: buccal, occlusal and palatal. To measure buccal distances in premolars, the buccal cusps were used as reference, while the mesiobuccal cusps were used for molars (Figure 1). For the measurements in which the occlusal areas were used as reference, the caliper was placed on the central area of the premolars' pit and on the central area of the mesial pit in molars (Figure 2). The references used for palatal measurements were the palatal cusps of premolars and mesiopalatal cusps of molars (Figure 3).

Height measurements of clinical crowns of canines were measured from their cusp to the highest point of concavity of the gingival margin. For premolars, the measurements were taken from the tip of the buccal cusp to the highest point of concavity of the gingival margin. However, the measurements of first molars were taken from the most occlusal margin of the buccal groove up to the gingival margin, directly under the buccal groove (Figure 4).

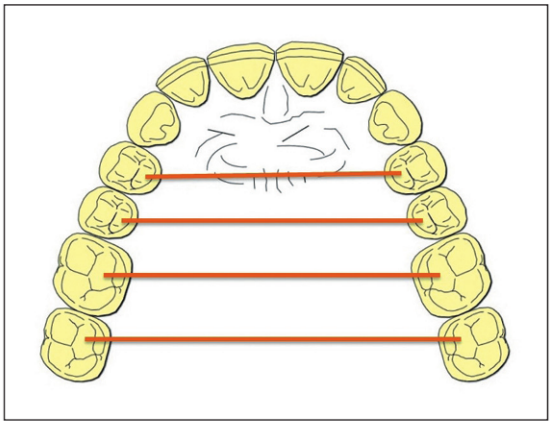

Figure 3.—Palatal distances measurements.

Figure 4.—Height measurements of clinical crown.

Statistical analysis

The analysis of the results obtained was carried out using the SPSS Statistics version 23.0. An analysis of the paired data obtained in the dental casts taken before and after treatment was performed using the Student's *t*-distribution test. The statistical descriptive data is presented using the mean and the standard deviation. All the measurements were repeated by the same observer after a two-week interval. The two sets of repeated measurements were used to calculate the method error using the Dahlberg's formula. Moreover, the intra-observer agreement for all the dental cast measurements using an intraclass correlation coefficient was calculated.

Results

The data obtained and the statistical analysis is presented in Table I, II. Table I displays the buccal, occlusal and palatal measurements obtained at the beginning (T_0) as well as at the end of treatment (T_1). A small variability is found in the increase of the interdental distance depending on the reference point used for this measurement: buccal, occlusal or palatal. The range is as follows: for the cuspid, 2.33 mm; for the first premolar, between 5.12 mm and 5.33 mm; for the second premolar between 5.43 mm and 5.84

TABLE I.—*Analysis of interdental distance measurements.*

Reference	Tooth	N.	Time	Mean	SD	T_1-T_0	P value
Buccal	First premolar	29	T_0	36.22	3.23	5.33	0.000
			T_1	41.55	2.08		
	Second premolar	24	T_0	40.85	4.01	5.84	0.000
			T_1	46.69	2.29		
	First molar	29	T_0	45.97	3.60	4.50	0.000
			T_1	50.47	3.20		
	Second molar	27	T_0	52.85	4.08	2.97	0.000
			T_1	55.82	3.65		
Occlusal	Canine	26	T_0	31.21	2.82	2.33	0.001
			T_1	33.54	1.36		
	First premolar	29	T_0	30.91	3.10	5.12	0.000
			T_1	36.03	1.86		
	Second premolar	24	T_0	35.63	3.76	5.43	0.000
			T_1	41.06	2.14		
	First molar	29	T_0	41.05	3.23	3.97	0.000
			T_1	45.02	3.13		
	Second molar	27	T_0	47.82	3.93	2.37	0.000
			T_1	50.19	3.45		
Palatal	First premolar	29	T_0	25.79	3.07	5.30	0.000
			T_1	31.09	1.97		
	Second premolar	24	T_0	30.54	3.99	5.65	0.000
			T_1	36.19	2.51		
	First molar	29	T_0	34.95	3.47	4.50	0.000
			T_1	39.45	3.65		
	Second molar	27	T_0	42.32	4.32	2.53	0.000
			T_1	44.85	3.75		

TABLE II.—*Analysis of clinical crown height measurements.*

Tooth	N.	Time	Mean	SD	T_1-T_0	P value
Canine	55	T_0	9.11	1.09	0.30	0.000
		T_1	9.41	1.05		
First premolar	58	T_0	7.11	1.17	0.44	0.000
		T_1	7.55	1.35		
Second premolar	47	T_0	5.86	1.07	0.26	0.002
		T_1	6.12	0.96		
First molar	58	T_0	4.98	1.07	0.14	0.062
		T_1	5.12	1.04		
Second molar	56	T_0	4.28	1.13	0.28	0.001
		T_1	4.56	1.01		

mm; for the first molar between 3.97 mm and 4.5 mm; and for the second molar between 2.37 mm and 2.97 mm. Statistically significant differences were found between the interdental widths for all pairs, with P<0.001 for all of them, except in the measurements of canines, in which the P=0.001.

Table II provides the measurements of clinical crown height at the beginning (T_0) and end (T_1) of treatment. The mean increase of the clinical height measurement at the end of treatment was 0.28 mm. Specifically, the range of buccal attachment loss was 0.30 mm for the cuspids; for the first bicuspids 0.44 mm; for the second bicuspids 0.26 mm; for the first molars 0.14 mm and for the second molars 0.28 mm. The difference between the right and left side of the arch was minimal for the measurements performed in all the teeth, with a range between 0.06 and 0.08 mm, except for the first premolars where the difference found was 0.22 mm. Since the Hyrax appliance was anchored onto the first premolars and first molars, it could be expected to obtain a greater degree of buccal attachment loss in these teeth. Indeed, that was the case for the first premolars that showed the maximal attachment loss; however, the first molars showed a completely opposite trend, presenting the smallest changes in clinical crown height measurements.

To assess the reliability of the results obtained by the examiners, each of the 58 dental casts was measured by a second, random examiner, each of whom compared the results with the original measurements and found no significant differences. When analyzing the interdental measurement of the upper canines, premolars, and molars at T_0 and T_1, the distance increases in all cases at the end of treatment and the increase is found in all the points of reference used for the same tooth: buccal, occlusal and palatal. The final height of the clinical crowns was lower than the initial height in a few cases. Since the measurements were performed once the gingival inflammation, if present at the end of treatment, had been eliminated, gum swelling could not be responsible for the decrease in the clinical crown height. It can be speculated that the gingival status of some teeth could have improved after treatment in spite of the expansion procedure due to a correction of their initial malposition, a better alignment or a correct occlusion. As mentioned before, this situation of a decreased height in the clinical crowns was very unusual for all the teeth but more frequently found for the first molars followed by the first premolars, canines, second molars, and second premolars, respectively. The method error values estimated using the Dahlberg's formula in the measurements before and after the maxillary expansion were 0.20 and 0.19, respectively. The intra-observer agreement for the dental cast measurements was 0.99.

Discussion

Nature of the study

This is a retrospective study and the subjects came from two private orthodontic offices; both factors may introduce a bias in terms of selection of the sample or variability in the treatment protocol. In order to minimize these limitations, all the subjects treated were included in the study as long as they met the aforementioned criteria with no other restriction. The treatment protocol was previously agreed by the two operators and the Hyrax expanders were fabricated in the same laboratory by the same technician. A limitation of this study is a lack of a control group. In the future, in order to minimize the impact of this methodological limitation, the sample size will be widened and the data of our experimental sample of patients will be compared with a matched control groups.

Efficacy/magnitude of expansion

The expansion obtained was of 4.5 mm for the first molar and 5.3 mm for the first bicuspid and

the results were statistically significant. This expansion was sufficient to correct the posterior crossbite in all cases but the amount of overexpansion (which is a part of the routine protocol used for maxillary expansion in growing individuals) was kept to a minimal in order to reduce the chances of potential complications. However, the amount of expansion performed in each case was decided upon the individual requirements of the malocclusion. In our study the sutural component of the expansion was not expected and, most likely, was not present in the majority of the cases, unlike what happens in growing patients. However, the amount of expansion obtained in our sample of adult patients is similar to the results reported by other studies in mixed dentition or in growing individuals.[28-30] As reported by Handelman,[17] maxillary expansion in the adult patients takes place at the dentoalveolar level with expansion of the teeth along with the alveolar process (rather than through it), bending of the alveolar processes and buccal tipping of the posterior teeth. The combination of these three components made the amount of expansion sufficient to correct the maxillary transverse deficiency in all cases, making the procedure clinically effective and efficient.

Hyrax *vs*. Haas appliance

Previous studies of nonsurgical maxillary expansion in adults have used the Haas expander,[14, 17] which is a tooth and tissue borne appliance. In our study, a Hyrax tooth borne expander anchored on the first permanent molars and first premolars was used. The Haas appliance is supported onto the palatal surface through the acrylic pads and provides pressure to the palatal vault, generating a force to the maxillary base, whereas the Hyrax transmits its force exclusively through the four anchor teeth, which might generate a greater amount of dental tipping. In our study, direct measurement of the molar tipping was not carried out but previous reports using the Haas appliance[17] reported 3º of molar tipping on each side as a result of the expansion procedure and it could be speculated that the buccal inclination of the molars could be greater with the Hyrax appliance; however, there is no clear evidence. In our study, the interarch increased measured at the mesiopalatal cusp of the first molars (4.5 mm) was similar to the one obtained by Handelman at the cervical contour of the palatal side of the molars (4.6 mm) but smaller than the one reported at the mesiopalatal cusp (5.7 mm). Therefore, Handelman found a greater amount of expansion at the palatal cusp level (5.7 mm) than at the cervical contour of the palatal side of the molars (4.6 mm). It could be argued that this difference is related to the molar tipping since the buccal inclination of the tooth might affect more the position of the palatal cusp than the position of the palatal surface of the molars. Since there is no direct estimation of the molar tipping, a similar correlation cannot be done in our study. However, in spite of the difference in the appliance design, the amount of expansion obtained in first premolars (5.3 mm) and second premolars (5.6 mm) in our study, measured at the palatal cusp level, was similar to the one reported with the Haas expander[17] (4.9 mm and 5.7 mm for the first and second premolar, respectively), measured at the cervical contour of the palatal side of the teeth.

What is the precise nature of the expansion in nonsurgical adult patients is a question that remains controversial. Handelman has proposed that the pressure of the acrylic pads of the Haas appliance against the palatal surface would induce remodeling of the palatal vault, generating an expansion that takes place mostly at the midpalatal level: he defines the process as maxillary alveolar expansion". Furthermore, in agreement with Epker *et al.*,[31] he advocates that bending of the palatal walls in a buccal direction would induce bone formation. While the data reported by Handelman is consistent with this concept, the interpretation that the acrylic pads of the Haas appliance are responsible for the remodeling is questionable. In our study the Hyrax appliance was used and the data obtained for the transversal measurements were in close agreement with the data reported with the Haas expander. Moreover, dentoalveolar expansion necessarily occurred in our experimental group in spite of using a tooth borne appliance. Otherwise, expansion would be a consequence of dental translation alone and, therefore, a severe degree of dental tipping would be found. Likely consequences of that would include the inability to generate a proper occlusion

and clinically significant gingival recessions in most cases. None of these parameters were observed in our study. Patients finished with a good settled occlusion and buccal attachment loss was minimal, without any clinical significance.

A continuation of the present study will consider a Cone Beam Computerized Tomography analysis in the repositioning of the teeth within the alveolar bone and the remodeling of the alveolar processes.

Morbidity/complications

Previous studies of nonsurgical palatal expansion are very limited. In 1987 Alpern and Yurosko published one of the few studies in which a maxillary expansion is carried out in adults with and without surgery.[13] Their study included a group of 82 patients with age lower than 25 years, in whom a maxillary expansion was performed without surgical assistance, and a second group of 25 patients with an average age of 30, who had undergone surgery before the expansion. Nonsurgical patients showed minimal discomfort. Maxillary expansion was carried out successfully in all cases. No lumps were felt during palpation, consistent with root fenestration. Moreover, the study stated that the expansion results were stable. This study provided important results regarding maxillary expansion in adults younger than 25 years, as the same clinical results were observed as in patients treated with surgery. In addition, no adverse effects were observed in association with the nonsurgical treatment. In 1996 Capelozza *et al.* published a study on 38 adult patients younger than 21 years old treated with maxillary expansion without surgery using the Haas appliance, activating the screw four-quarter turns a day in order to split the palate.[14] The article states that the expansion was successful in most cases, as a diastema was created in the central incisors in 81.5% of the patients. However, side effects varied from mild discomfort to pain, swelling, and palatal injuries in 78% of the patients, although in most cases such effects did not compromise the expansion. Moderate maxillary expansion, enough to provide a satisfactory occlusion, was achieved in most cases; however, the frequency of complications seemed somewhat discouraging. More recently, in a study including 47 adult patients who underwent nonsurgical palatal expansion with the Haas appliance activating the screw every other day, Handelman reported palatal swelling and pain in nine of them and headaches in one patient. In our study the expansion was performed with the Hyrax appliance activating the screw every two days and palatal swelling was not a complication in any of them. Initial discomfort was a common finding but patients were instructed to stop the expansion if acute pain was present: that was not necessary in any of the patients. Special care was taken in appliance design and fabrication in order to obtain a correct adjustment with bands not invading the gingival sulcus of the anchor teeth. Pericoronal inflammation of the gingival contour was not observed and the appliance showed a good tolerance throughout the expansion procedure. According to these data, it is tempting to conclude that the level of morbidity can be kept to a minimum if certain parameters are taken into consideration. Namely, a good adjustment and fabrication of the appliance, activation of the screw no faster than one turn every other day and age of the patients below 30 years.

Gingival recession

Clinical crown height changes were measured for cuspids, first and second premolars and first and second molars on both sides as an estimation of buccal attachment loss for these teeth. Measurements for the right and left side were very close and did not show a statistically significant difference. Analysis of the data was performed for males and females together. The mean increase at the end of treatment was 0.28 mm, smaller than the one reported by Handelman of 0.55 mm. Similarly, the comparison of our measurements on premolars and first molars with the results obtained by Handelman showed relevant differences for the first molar measurements, because we obtained a mean difference of 0.14 mm while Handelman reported 0.3 mm of mean difference for the male subgroup and 0.6 mm for the female subgroup. These differences cannot be explained by the amount of expansion, very similar in both studies, but for other factors such as the mean age of the subjects, the initial clinical crown height, the preexisting periodontal

status,[32] or the different protocol used for overcorrection in the patients.

Buccal attachment loss is a common finding in adult orthodontic treatment but this does not necessarily cause a gingival recession. It has been reported that recession does not take place unless 3 mm of attachment loss is present.[33] In the present study the level of attachment loss was of a much lesser degree and root exposure was not evident in any of the cases. However, the increased height of the clinical crowns was of 0.44 mm for the first premolars. This clinical crown elongation, even if it did not carry out a gingival recession, could be considered meaningful since it is unlikely to happen without an active expansion in adult patients. Therefore, caution should be advised in those patients undergoing this procedure if they exhibit, prior to the treatment, a limited thickness of the cortical bone at the level of the bicuspid area assessed either by clinical examination or by CBCT evaluation.

Conclusions

The nonsurgical maxillary expansion carried out in a group of 29 adult patients allowed for the correction of unilateral and bilateral crossbites. The appliance used was a properly fabricated and adjusted Hyrax expander and the protocol prescribed to turn the screw one time every other day.

The increase in the interdental widths at the end of treatment was of 4.3 mm for the first molars, 5.3 mm for the first premolars and 5.6 mm for the second premolars. These results are extremely close to the ones reported by Handelman both in adults and children undergoing expansion with the Haas appliance.[17]

After a follow-up retention period of 3±6 years, no relapse of the crossbite was clinically observed and the transverse occlusal coordination seemed to be correct in all the patients.

Measurements of the dental tipping were not directly performed, however the palatal cusp, occlusal fossa and buccal cusp level measurements before and after treatment were extremely close.

Gingival recession was not observed in any of the patients, buccal attachment loss was present but to a minor degree; then differences in clinical crown height were not clinically significant and did not carry out adverse consequences.

Therefore, nonsurgical maxillary expansion performed with the Hyrax appliance can be proposed as a safe and treatment alternative to the surgically assisted maxillary expansion to correct transverse deficiencies in adult patients, especially in patient below 30 years of age with healthy periodontal status. Further research is necessary in order to improve and expand the limited amount of data currently available in this promising field.

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