ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/dentalsci.2022-89864

Comparison of Rapid and Semi-Rapid Maxillary Expansion Efficiency According to Skeletal Maturation Stages: A Retrospective Study

Hızlı ve Yarı Hızlı Maksiller Genişletme Etkinliğinin İskeletsel Maturasyon Aşamalarına Göre Karşılaştırılması: Retrospektif Bir Çalışma

Shahin MAMMADLI[a], Sibel AKBULUT[a], Ahmet YAĞCI[b]

[a]Department of Orthodontics, Tokat Gaziosmanpaşa University Faculty of Dentistry, Tokat, Türkiye
[b]Department of Orthodontics, Erciyes University Faculty of Dentistry, Kayseri, Türkiye

ABSTRACT Objective: This study aimed to compare the skeletal and dentoalveolar effects of the expansion force created by the semi-rapid and rapid activation protocols. **Material and Methods:** The study comprised 54 patients (26 female and 28 male) with transverse maxillary insufficiency. Of these patients, 22 were treated with semi-rapid maxillary expansion (SRME) and 32 with rapid maxillary expansion (RME). The SRME group consisted of 6 prepubertal, 8 pubertal, and 8 postpubertal patients, and the RME group consisted of 11 prepubertal, 11 pubertal, and 10 postpubertal patients. Treatment effects with both protocols were evaluated with 11 different measurements on posteroanterior cephalograms and plaster models taken before treatment and after a retention period of 3 months. Kruskal-Wallis analysis was used for comparisons between different maturation periods. Independent sample t-test and Mann-Whitney U test with Bonferroni correction were used for pairwise comparisons between two different activation protocols. **Results:** The increases in nasal and dental widths in the SRME group were found to be higher than in the RME group in the prepubertal patient group ($p<0.05$). There was no significant difference between the SRME and RME groups in pubertal and postpubertal groups ($p>0.05$). No statistically significant difference was found among prepubertal, pubertal, and postpubertal groups for all skeletal and dental measurements ($p>0.05$). **Conclusion:** The current study represented some evidence that the SRME activation protocol might cause less tissue resistance than the conventional RME. The efficiency of maxillary expansion therapy is similar in prepubertal, pubertal, and postpubertal patients in whom sutural resistance is resolved.

Keywords: Orthopedics; dentofacial deformities; palatal expansion technique

ÖZET Amaç: Bu çalışmanın amacı, yarı hızlı ve hızlı aktivasyon protokollerinin oluşturduğu genişleme kuvvetinin iskeletsel ve dentoalveolar etkilerini karşılaştırmaktır. **Gereç ve Yöntemler:** Çalışmaya transversal maksiller yetersizliği olan 54 hasta (26 kadın ve 28 erkek) dâhil edildi. Bu hastalardan 22'si yarı hızlı üst çene genişletmesi [semi-rapid maxillary expansion (SRME)] ve 32'si hızlı üst çene genişletmesi [rapid maxillary expansion (RME)] ile tedavi edilmişti. SRME grubu 6 prepubertal, 8 pubertal ve 8 postpubertal hastadan ve RME grubu 11 prepubertal, 11 pubertal ve 10 postpubertal hastadan oluşuyordu. Her iki protokolün de tedavi etkileri, tedaviden önce ve ortalama 3 aylık retansiyon döneminden sonra her hastadan alınan posteroanterior sefalogramlar ve alçı modelleri üzerinde 11 farklı ölçümle değerlendirildi. Farklı maturasyon dönemleri arasındaki karşılaştırmalar için Kruskal-Wallis analizi kullanıldı. İki farklı aktivasyon protokolü arasında ikili karşılaştırmalar için bağımsız örnek t-testi ve Bonferroni düzeltmeli Mann-Whitney U testi kullanıldı. **Bulgular:** Prepubertal hasta grubunda, SRME grubundaki nazal ve dental genişlik artışları RME grubuna göre daha yüksek bulundu ($p<0,05$). Pubertal ve postpubertal gruplarda SRME ve RME grupları arasında anlamlı fark yoktu ($p>0,05$). Tüm iskeletsel ve dental ölçümler için prepubertal, pubertal ve postpubertal gruplar arasında istatistiksel olarak anlamlı bir fark bulunmadı ($p>0,05$). **Sonuç:** Mevcut çalışma, SRME aktivasyon protokolünün geleneksel RME'den daha az doku direncine neden olabileceğine dair bazı kanıtlar sundu. Sütüral direncin çözüldüğü prepubertal, pubertal ve postpubertal hastalarda maksiller genişletme tedavisinin etkinliği benzerdir.

Anahtar Kelimeler: Ortopedi; dentofasiyal deformiteler; palatal genişletme tekniği

Correspondence: Sibel AKBULUT
Department of Orthodontics, Ondokuz Mayıs University Faculty of Dentistry, Samsun, Türkiye
E-mail: dt.sibelakbulut@hotmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Dental Sciences.

Received: 22 Mar 2022 ***Received in revised form:*** 24 May 2022 ***Accepted:*** 26 Oct 2022 ***Available online:*** 01 Nov 2022

Vertical, sagittal, and transversal orthodontic anomalies can be seen in the dentofacial complex. One of the most common anomalies seen in the transversal direction is posterior crossbite.[1] When posterior crossbite is associated with a narrow apical-basal bone, the treatment includes rapid maxillary expansion (RME). In RME applications, it is aimed to separate the median palatal suture and expand the maxillary base. Surgically-assisted RME is indicated due to the increase in ossification in the mid-palatal and circummaxillary sutures in adults, while the forces applied with screw activation can provide separation in the median palatal suture in children and adolescents.

In the literature, there are various designs of RME appliances (tooth-borne, tooth-tissue borne, tooth-bone borne, or bone borne) and screw activation protocols applied with them. However, there is no consensus on the optimal force or optimal screw activation protocol to be applied.[2] Although many researchers prefer 2 quarter turns of activation per day (2QD), some researchers suggest a slower semi-rapid maxillary expansion (SRME) to produce less tissue resistance and minimalize residual stress for a stable outcome.[3-8] Although a limited number of studies comparing activation protocols have tried to shed light on this issue, the evidence is still unclear that which rate of activation causes greater skeletal expansion and less dental tipping and therefore benefits patients the most.[2]

The primary aim of this retrospective study was to compare the dental and skeletal outcomes of conventional RME with a constant protocol of 2QD and SRME with a decreasing activation protocol. And the secondary aim was to compare the treatment outcomes among prepubertal, pubertal, and postpubertal patients.

MATERIAL AND METHODS

Ethical approval was obtained from the local ethics Committee of Tokat Gaziosmanpaşa University (date: 27.08.2020, no: 20-KAEK-227). The study was conducted as per the principles of the Helsinki Declaration. Routinely obtained written consent forms before starting the treatment which included the use of patients' records in scientific studies were checked.

The archives of the Tokat Gaziosmanpaşa and Erciyes Universities were scanned for SRME or RME applied patients with an acrylic cap-splint appliance (Figure 1) between the years 2015-2021. Exclusion criteria were as follows:

- Having missing teeth in the upper arch, except third molars
- Applied additional fixed and/or removable orthodontic mechanics during the expansion and retention period (like vertical chin cap or posterior cross elastics)
- Having any dentofacial anomaly
- Interrupted treatment because of mucosal ulceration or severe pain after activation of the expansion screw

The patients were classified according to cervical vertebral maturation stages (CVMS) and then divided into three groups as prepubertal (CVMS1-CVMS2), pubertal (CVMS3-CVMS4), and postpubertal (CVMS5-CVMS6). Then, a second classification was done according to activation protocols (rapid or semi-rapid expansion). The distribution of the patients according to their developmental stages and activation protocols is given in Table 1.

Two different activation protocols were applied to the patients. In the RME group, a constant 2QD activation was applied during the entire expansion period. In the SRME group the semi-rapid activation protocol was applied as 2QD for the first 3 days, 1 quarter turn per day for the next 4 days, and 1 quar-

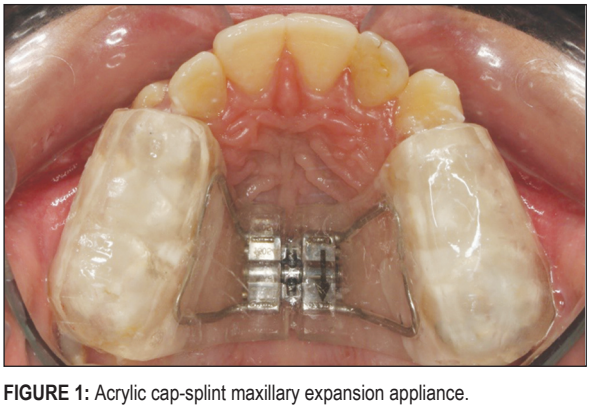

FIGURE 1: Acrylic cap-splint maxillary expansion appliance.

TABLE 1: Comparison of the patient numbers, skeletal maturation stages, and chronological ages between the SRME and RME groups.

	SRME	RME	
Sex	n (F+M)	n (F+M)	p¥
Prepubertal	6 (3F+3M)	11 (5F+6M)	0.999
Pubertal	8 (4F+4M)	11 (5F+6M)	0.999
Postpubertal	8 (2F+6M)	10 (7F+3M)	0.153
CVMS	n	n	p$^{\epsilon}$
Prepubertal	4 (C1)+2 (C2)	7 (C1)+4 (C2)	0.999
Pubertal	1 (C3)+7 (C4)	5 (C3)+6 (C4)	0.177
Postpubertal	3 (C5)+5 (C6)	8 (C5)+2 (C6)	0.145
Chronological age	$\bar{X}$±SD	$\bar{X}$±SD	p¥
Prepubertal	11.90±1.08	12.18±1.39	0.880
Pubertal	14.77±1.65	13.28±1.54	**0.048***
Postpubertal	16.57±1.52	13.70±1.66	**0.004***

SRME: Semi-rapid maxillary expansion; RME: Rapid maxillary expansion; n: Patient number; F: Female; M: Male; p¥: Results of Mann-Whitney U test; CVMS: Cervical vertebral maturation stages; p$^{\epsilon}$: Results of Fisher exact chi-square test; SD: Standard deviation. *: p<0.05.

ter-turn per 2 days (1 day activated, 1 day waited) for the following days. When the expansion screws in both groups are turned 1 quarter turn, they provide 0.2 mm activation. The total number of screw activations applied according to the needs of the patients were recorded in the patient files. When the adequate maxillary expansion was achieved (upper molar palatine cusp to the level of lower molar central fossa), the expansion screw was fixed with a light-cured composite or ligature wire. During the three-month retention period, the expansion appliance was left in the mouth.

Plaster models, posteroanterior and lateral cephalometric films taken routinely from patients before expansion (T0) and after 3 months of retention (T1) were obtained from archive records.

The following dental measurements were performed on the plaster models with the help of a digital caliper and digital protractor:

1) Occlusal distance between the upper right and left teeth #3, #4, #5, and #6 (the most incisal point for the canines and central fossa points for the teeth #4, #5, and #6 were used) (Figure 2)

2) Gingival distance between the upper right and left teeth #3, #4, #5, and #6 (The deepest point of the palatal gingival margin was taken as reference.)

FIGURE 2: The measurement of the occlusal distance between the right and left first molars.

3) The angle formed by the planes passing through the mesiopalatinal and mesiobuccal cusps of the upper right and left first molars (Figure 3)

The following skeletal measurements were performed using Dolphin® imaging software (Version 11.5, Patterson Dental Supply, Chatsworth, CA, USA) on the posteroanterior cephalograms (Figure 4):

1. Nasal width (distance between the most convex points on the right and left lateral nasal walls)

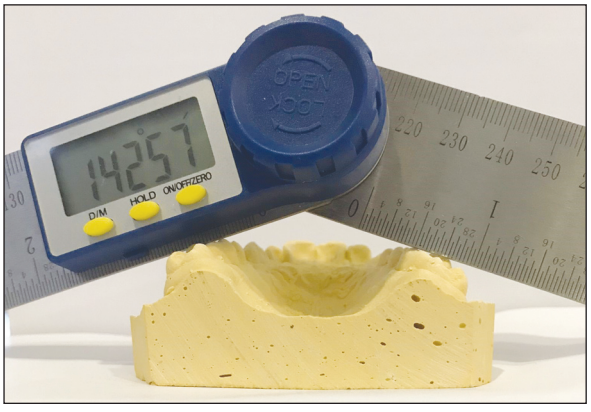

FIGURE 3: The measurement of the angle between the right and left first molar occlusal surfaces.

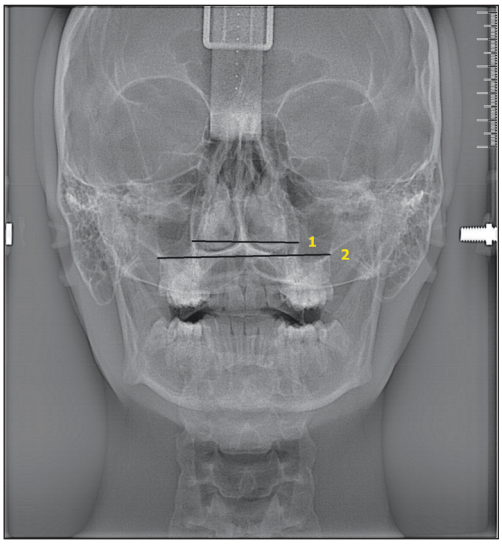

FIGURE 4: The skeletal measurements used in posteroanterior cephalograms (1: nasal width, 2: maxillary width).

2. Maxillary width (distance between the right and left jugale points)

Standardization of the number of activations could not be achieved, as patients needed different amounts of expansion at the beginning of treatment. The maxillary expansion efficiency of all measurements was calculated using the following formula to avoid false results of the study that might be seen with different expansion amounts.

$$\text{RME efficiency} = \frac{distance\ increase\ (mm)}{number\ of\ activation}$$

To determine the reliability of the measurements, all measurement procedures of 16 randomly selected patients were repeated 2 months after the first measurements.

STATISTICAL ANALYSIS

IBM SPSS Statistics 19 (SPSS Inc., IBM Co, Somers, NY) package program was used for the statistical analysis. Paired sample t-test and Pearson correlation analysis were used to determine method error. Kruskal-Wallis analysis was used for comparisons between different maturation periods. Independent sample t-test and Mann-Whitney U test with Bonferroni correction were used for pairwise comparisons between two different activation protocols.

RESULTS

After the post-power analysis, using the G Power 3.19.7 program (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany), it was found that at least 50 patients should be included in the study with 80% effect size and 85% power. The intra-examiner reliability was high with no significant difference (p=0.79) and high correlation (r=0.99) between the measurements that were performed at different intervals.

The increasing amount of expansion from nasal to occlusal widths was observed in agreement with the nature of the triangular opening in the RME (Table 2, Table 3, Table 4, Table 5, Table 6).

With pooling all the maturation groups, no statistically significant difference was found between the SRME and RME groups for all skeletal measurements (p>0.05). Of the dental measurements, two distance measurements (3-3O and 6-6G) were found to increase significantly more in the SRME than in the RME group (for every 1 quarter-turn of screw activation) (p=0.04 and p=0.02 respectively). All the remaining dental measurements were not statistically significant between the SRME and RME groups (p>0.05) (Table 2).

When the SRME and RME groups were compared in the prepubertal group, no significant difference was found in maxillary width (p>0.05), while the nasal width increase was higher in the SRME group than in the RME group (p=0.21). Regarding dental measurements, buccal tipping of the first molar was similar between the two groups (p=0.62), while

TABLE 2: Comparison of the maxillary expansion efficiency between the SRME and RME groups (with pooling all the maturation groups).

All patients	SRME (n=22) $\bar{X}$±SD	RME (n=32) $\bar{X}$±SD	p¥
Nasal width	0.07±0.04	0.06±0.05	0.52
Maxillary width	0.08±0.06	0.10±0.08	0.34
3-3 (O) (mm)	0.14±0.08	0.09±0.03	0.04*
3-3 (G) (mm)	0.14±0.08	0.10±0.04	0.05
4-4 (O) (mm)	0.18±0.05	0.16±0.04	0.08
4-4 (G) (mm)	0.17±0.05	0.16±0.03	0.13
5-5 (O) (mm)	0.19±0.06	0.17±0.04	0.19
5-5 (G) (mm)	0.18±0.05	0.16±0.04	0.06
6-6 (O) (mm)	0.19±0.05	0.17±0.04	0.10
6-6 (G) (mm)	0.19±0.05	0.16±0.04	**0.02***
6-6 (°)	0.20±0.15	0.23±0.18	0.52

*p<0.05; SRME: Semi-rapid maxillary expansion; RME: Rapid maxillary expansion; SD: Standard deviation; p¥: Results of independent samples t-test O: Occlusal distance; G: Gingival distance.

TABLE 3: Comparison of the maxillary expansion efficiency between the SRME and RME groups in prepubertal patients.

Prepubertal patients	SRME (n=6) $\bar{X}$±SD	RME (n=11) $\bar{X}$±SD	p¥
Nasal width	0.09±0.03	0.04±0.05	**0.021***
Maxillary width	0.13±0.06	0.08±0.08	0.097
3-3 (O) (mm)	0.21±0.05	0.08±0.02	**0.001***
3-3 (G) (mm)	0.20±0.06	0.08±0.04	**0.005***
4-4 (O) (mm)	0.23±0.04	0.15±0.04	**0.003***
4-4 (G) (mm)	0.23±0.04	0.14±0.03	**0.002***
5-5 (O) (mm)	0.25±0.04	0.16±0.04	**0.003***
5-5 (G) (mm)	0.24±0.04	0.15±0.05	**0.002***
6-6 (O) (mm)	0.25±0.05	0.17±0.05	**0.012***
6-6 (G) (mm)	0.23±0.04	0.16±0.04	**0.004***
6-6 (°)	0.21±0.10	0.20±0.14	0.615

*p<0.05; SRME: Semi-rapid maxillary expansion; RME: Rapid maxillary expansion; SD: Standard deviation; p¥: Results of Mann-Whitney U test with Bonferroni correction; O: Occlusal distance; G: Gingival distance.

TABLE 4: Comparison of the maxillary expansion efficiency between the SRME and RME groups in pubertal patients.

Pubertal patients	SRME (n=8) $\bar{X}$±SD	RME (n=11) $\bar{X}$±SD	p¥
Nasal width	0.06±0.05	0.08±0.04	0.43
Maxillary width	0.05±0.02	0.11±0.09	0.19
3-3 (O) (mm)	0.12±0.06	0.11±0.04	0.86
3-3 (G) (mm)	0.14±0.06	0.10±0.05	0.46
4-4 (O) (mm)	0.18±0.05	0.17±0.04	0.74
4-4 (G) (mm)	0.17±0.05	0.16±0.03	0.99
5-5 (O) (mm)	0.18±0.04	0.18±0.05	0.74
5-5 (G) (mm)	0.17±0.03	0.17±0.04	0.93
6-6 (O) (mm)	0.20±0.04	0.18±0.04	0.26
6-6 (G) (mm)	0.19±0.04	0.16±0.05	0.08
6-6 (°)	0.21±0.12	0.22±0.14	0.87

SRME: Semi-rapid maxillary expansion; RME: Rapid maxillary expansion; SD: Standard deviation; p¥: Results of Mann-Whitney U test; O: Occlusal distance; G: Gingival distance.

TABLE 5: Comparison of the maxillary expansion efficiency between the SRME and RME groups in postpubertal patients.

Postpubertal patients	SRME (n=8) $\bar{X}$±SD	RME (n=10) $\bar{X}$±SD	p¥
Nasal width	0.05±0.04	0.06±0.05	0.50
Maxillary width	0.07±0.05	0.10±0.07	0.21
3-3 (O) (mm)	0.07±0.04	0.09±0.03	0.45
3-3 (G) (mm)	0.06±0.05	0.10±0.03	0.26
4-4 (O) (mm)	0.15±0.05	0.16±0.04	0.82
4-4 (G) (mm)	0.14±0.04	0.16±0.04	0.21
5-5 (O) (mm)	0.15±0.05	0.17±0.05	0.53
5-5 (G) (mm)	0.15±0.05	0.16±0.04	0.93
6-6 (O) (mm)	0.15±0.04	0.17±0.03	0.69
6-6 (G) (mm)	0.15±0.06	0.16±0.03	0.66
6-6 (°)	0.18±0.22	0.28±0.24	0.33

SRME: Semi-rapid maxillary expansion; RME: Rapid maxillary expansion; SD: Standard deviation; p¥: Results of Mann-Whitney U test; O: Occlusal distance; G: Gingival distance.

TABLE 6: Comparison of the maxillary expansion efficiency among the maturation periods.

All patients	Prepubertal (n=17) $\bar{X}$±SD	Pubertal (n=19) $\bar{X}$±SD	Postpubertal (n=18) $\bar{X}$±SD	p¥
Nasal width	0.06±0.05	0.07±0.04	0.06±0.05	0.43
Maxillary width	0.10±0.08	0.09±0.08	0.09±0.06	0.65
3-3 (O) (mm)	0.13±0.07	0.11±0.05	0.08±0.03	0.19
3-3 (G) (mm)	0.13±0.08	0.12±0.05	0.09±0.04	0.44
4-4 (O) (mm)	0.18±0.05	0.18±0.04	0.16±0.05	0.26
4-4 (G) (mm)	0.17±0.05	0.17±0.04	0.15±0.04	0.53
5-5 (O) (mm)	0.19±0.06	0.18±0.05	0.17±0.05	0.36
5-5 (G) (mm)	0.18±0.06	0.17±0.04	0.15±0.04	0.31
6-6 (O) (mm)	0.20±0.06	0.19±0.04	0.16±0.04	0.08
6-6 (G) (mm)	0.19±0.05	0.17±0.05	0.16±0.05	0.24
6-6 (°)	0.20±0.13	0.22±0.13	0.23±0.23	0.78

SD: Standard deviation; p¥: Results of Kruskal-Wallis variance analysis; O: Occlusal distance; G: Gingival distance.

the increases in all dental distances was statistically higher in the SRME group ($p<0.05$) which indicates more dental expansion in the SRME group than in the RME group (Table 3).

When the SRME and RME groups in pubertal and postpubertal maturation periods were compared, no statistical difference was found in all skeletal and dental measurements ($p>0.05$) (Table 4 and Table 5).

No statistically significant difference was found among prepubertal, pubertal, and postpubertal groups in all skeletal and dental measurements ($p>0.05$) (Table 6).

DISCUSSION

There are limited studies in the literature comparing the outcomes of the semi-rapid and rapid maxillary expansion. In most of these studies, the amount of expansion was adjusted according to the patients' requirements.[9-11] However, different amounts of activations affect the amount of skeletal and dental outcomes and might compromise the real difference between the two activation protocols. To eliminate this limitation, the treatment efficacy was evaluated by dividing the expansion amounts by the number of activations in the current study.[12] In

addition, since chronological age is not always correlated with skeletal maturation, the groups of the current study were formed by considering the skeletal maturation periods, instead of the chronological ages. Therefore, the present study provides reliable results in these respects.[13]

A bonded maxillary expansion device was used in the current study. The bonded expanders were considered as a conventional method and preferred by the clinicians as it is not invasive and easy to apply with relatively lower costs than a bone-borne or banded maxillary expansion appliance.[14,15] Also, bonded maxillary expansion devices with occlusal coverage were more advantageous than the banded expanders as they limit the undesirable effects of maxillary expansion like molar tipping and an increase in vertical facial heights.[16,17] Supporting the literature, upper molar inclinations were found as stable after orthopedic maxillary expansion with a bonded expander, even in postpubertal patients, in the current study. Therefore, using bonded expanders with occlusal coverage might be still considered a reasonable option in most of the orthodontic patients.

Regarding the effects of expansion rate, there is a lack of studies comparing different maxillary expansion protocols[2], and the existing comparative literature includes some important limitations such as not considering the number of activations.[9-11] These studies also vary regarding the application of different activation protocols. Therefore, there are different results reported in the literature. Ramoglu and Sari compared the effects of RME and SRME in the mixed dentition and found similar skeletal and dental effects both in the transverse, vertical, and sagittal planes.[9] Perillo et al. compared the dento-skeletal effects of RME and mixed maxillary expansion (MME: very rapid activation in the first visit until the suture was opened, then slow activation with one turn every 3 days) in prepubertal patients.[10] They found statistically similar skeletal effects in both groups, while MME was found to cause minor dental side effects compared to RME.[10] Baldini et al. compared dental arch changes associated with different activation protocols (1 quarter vs 2 quarters daily) by using an adjustment method that was used in the current study too.[12] They found greater increases with the faster activation protocol both in the inter-canine and intermolar distances.

As for the current results, for the prepubertal group, although the difference in maxillary width was not statistically significant, higher nasal and maxillary width increases were observed in the SRME than those in the RME group. Also, the dental distance increases were higher in the SRME group. Therefore, these results might support that the SRME protocol produces less tissue resistance in dentofacial structures.[6] On the other hand, no statistical difference was found between the SRME and RME groups in pubertal and postpubertal groups. The reason for that result was attributed to the inhomogeneous distribution of the maturation stages between the SRME and RME groups. It becomes more important especially in pubertal and postpubertal patients due to the advancing maturity in these periods. This inhomogeneity was evident in the comparison of chronological ages in pubertal and postpubertal groups. Although the skeletal maturation stages between the groups were tried to be equalized in the current study, the patients in the RME group were younger than those in the SRME group. Therefore, the results might be negatively affected in pubertal and postpubertal groups.

In the current study, the short-term results of maxillary expansion were also compared among prepubertal, pubertal, and postpubertal periods, and statistically similar skeletal and dental outcomes were found among the groups. In line with our results, Baccetti et al. compared early (CVMS 1 to 3) and late (CVMS 4 to 6) applied RME results with the same amounts of expansion in both groups, and found statistically similar dental and skeletal outcomes in the early and late treated RME groups, except for nasal width changes in the short-term.[18] In another study, comparing the short-term RME results according to midpalatal maturation stages, no significant difference was found between pre-peak and post-peak groups regarding skeletal and dental outcomes.[19] In that study, in which equal RME activation numbers were applied for each patient, the mean increases in maxillary width in the pre-peak and post-peak groups were reported to be almost equal (2.91 vs. 2.92).[19] Although there is a general belief that RME treatment has a more skeletal effect when applied in the early

period and more dentoalveolar when applied in the later stages, the current study suggested that once the sutural resistance is resolved, similar amounts of skeletal and dental outcomes might be obtained among prepubertal, pubertal, and postpubertal patients. On the other hand, due to increasing sutural maturity in the post-pubertal period, increased possibility of failure in opening the midpalatal suture should be taken into account. Also, the relapse amounts might be different among individuals with different maturation periods.[18]

This retrospective study had some limitations. The inhomogeneous distribution of the patients and the relatively small number of patients in the prepubertal group were the main limitations. Also, since the previous studies used different protocols we were unable to compare the results of the current study with the previous ones. Therefore, there is a still need for studies comparing different activation protocols with larger sample sizes, homogeneous patient groups, and considering activation numbers. Whether there is a difference between the protocols in terms of pain, discomfort, and relapse could be the subject of future studies.

CONCLUSION

The following conclusions can be drawn from the current study:

- The current study represented some evidence that the SRME activation protocol might cause less tissue resistance than conventional RME.
- The efficiency of maxillary expansion therapy is similar in prepubertal, pubertal, and postpubertal patients in whom sutural resistance is resolved.
- Bonded maxillary expansion appliance with occlusal coverage limits the buccal tipping of the molar teeth during maxillary expansion.

Acknowledgement

Thanks to lecturer Yunus Emre KUYUCU for the statistical analysis from the Department of Biostatistics at Tokat Gaziosmanpaşa University.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Sibel Akbulut; **Design:** Sibel Akbulut; **Control/Supervision:** Sibel Akbulut, Ahmet Yağcı; **Data Collection and/or Processing:** Shahin Mammadlı, Ahmet Yağcı; **Analysis and/or Interpretation:** Sibel Akbulut, Shahin Mammadlı; **Literature Review:** Sibel Akbulut, Shahin Mammadlı; **Writing the Article:** Shahin Mammadlı, Sibel Akbulut; **Critical Review:** Sibel Akbulut, Ahmet Yağcı; **Materials:** Ahmet Yağcı, Shahin Mammadlı, Sibel Akbulut.*

REFERENCES

1. Mehta S, Wang D, Kuo CL, Mu J, Vich ML, Allareddy V, et al. Long-term effects of mini-screw-assisted rapid palatal expansion on airway. Angle Orthod. 2021;91(2):195-205. [Crossref] [PubMed] [PMC]
2. Algharbi M, Bazargani F, Dimberg L. Do different maxillary expansion appliances influence the outcomes of the treatment? Eur J Orthod. 2018;40(1):97-106. [Crossref] [PubMed]
3. Gunyuz Toklu M, Germec-Cakan D, Tozlu M. Periodontal, dentoalveolar, and skeletal effects of tooth-borne and tooth-bone-borne expansion appliances. Am J Orthod Dentofacial Orthop. 2015;148(1):97-109. [Crossref] [PubMed]
4. Mosleh MI, Kaddah MA, Abd ElSayed FA, ElSayed HS. Comparison of transverse changes during maxillary expansion with 4-point bone-borne and tooth-borne maxillary expanders. Am J Orthod Dentofacial Orthop. 2015;148(4):599-607. [Crossref] [PubMed]
5. Weissheimer A, de Menezes LM, Mezomo M, Dias DM, de Lima EM, Rizzatto SM. Immediate effects of rapid maxillary expansion with Haas-type and hyrax-type expanders: a randomized clinical trial. Am J Orthod Dentofacial Orthop. 2011;140(3):366-76. [Crossref] [PubMed]
6. Işeri H, Ozsoy S. Semirapid maxillary expansion--a study of long-term transverse effects in older adolescents and adults. Angle Orthod. 2004;74(1):71-8. [PubMed]
7. Zimring JF, Isaacson RJ. Forces produced by rapid maxillary expansion. 3. forces present during retention. Angle Orthod. 1965;35:178-86. [PubMed]
8. Işeri H, Tekkaya AE, Oztan O, Bilgiç S. Biomechanical effects of rapid maxillary expansion on the craniofacial skeleton, studied by the finite element method. Eur J Orthod. 1998;20(4):347-56. [Crossref] [PubMed]

9. Ramoglu SI, Sari Z. Maxillary expansion in the mixed dentition: rapid or semi-rapid? Eur J Orthod. 2010;32(1):11-8. [Crossref] [PubMed]
10. Perillo L, De Rosa A, Iaselli F, d'Apuzzo F, Grassia V, Cappabianca S. Comparison between rapid and mixed maxillary expansion through an assessment of dento-skeletal effects on posteroanterior cephalometry. Prog Orthod. 2014;15(1):46. [Crossref] [PubMed] [PMC]
11. Grassia V, d'Apuzzo F, Jamilian A, Femiano F, Favero L, Perillo L. Comparison between rapid and mixed maxillary expansion through an assessment of arch changes on dental casts. Prog Orthod. 2015;16:20. [Crossref] [PubMed] [PMC]
12. Baldini A, Nota A, Santariello C, Assi V, Ballanti F, Cozza P. A comparative assessment of changes in dental arches associated with different activation protocols of rapid maxillary expansion. Eur J Paediatr Dent. 2018;19(1):35-9. [PubMed]
13. Alkhal HA, Wong RW, Rabie AB. Correlation between chronological age, cervical vertebral maturation and Fishman's skeletal maturity indicators in southern Chinese. Angle Orthod. 2008;78(4):591-6. [Crossref] [PubMed]
14. Yılmaz A, Arman-Özçırpıcı A, Erken S, Polat-Özsoy Ö. Comparison of short-term effects of mini-implant-supported maxillary expansion appliance with two conventional expansion protocols. Eur J Orthod. 2015;37(5):556-64. [Crossref] [PubMed]
15. Çörekçi B, Göyenç YB. Dentofacial changes from fan-type rapid maxillary expansion vs traditional rapid maxillary expansion in early mixed dentition. Angle Orthod. 2013;83(5):842-50. [Crossref] [PubMed] [PMC]
16. Olmez H, Akin E, Karaçay S. Multitomographic evaluation of the dental effects of two different rapid palatal expansion appliances. Eur J Orthod. 2007;29(4):379-85. [Crossref] [PubMed]
17. Pangrazio-Kulbersh V, Wine P, Haughey M, Pajtas B, Kaczynski R. Cone beam computed tomography evaluation of changes in the naso-maxillary complex associated with two types of maxillary expanders. Angle Orthod. 2012;82(3):448-57. [Crossref] [PubMed] [PMC]
18. Baccetti T, Franchi L, Cameron CG, McNamara JA Jr. Treatment timing for rapid maxillary expansion. Angle Orthod. 2001;71(5):343-50. [PubMed]
19. Sayar G, Kılınç DD. Rapid maxillary expansion outcomes according to midpalatal suture maturation levels. Prog Orthod. 2019;20(1):27. [Crossref] [PubMed] [PMC]