Effect of the pterygomaxillary disjunction on surgically assisted rapid palatal expansion in context of orthodontic treatment

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Objective. This retrospective study analyzed the dentoalveolar effects of pterygomaxillary disjunction (PMD) in surgically assisted rapid palatal expansion (SARPE) after orthodontic treatment.

Study Design. Virtual study casts before and after orthodontic treatment involving SARPE were analyzed in 12 patients without (−) PMD and 15 patients with (+) PMD. Linear and angular measurements and maximum deviations on the alveolar ridge and hard palate were determined.

Results. Dental arch widths in the first molars of the (−) and (+) PMD groups increased to 6.07 ± 2.11 mm and 6.61 ± 2.33 mm ($P = .96$) and the corresponding axial angles increased to 0.34 ± 9.45 degrees and 2.39 ± 9.59 degrees ($P = .58$), respectively. The palatal angles changed by about 0.10 ± 11.50 degrees and 1.74 ± 14.56 degrees ($P = .75$) in the (−) and (+) PMD groups and the maximum labial deviations at the alveolar ridge were 3.04 ± 0.76 mm and 3.22 ± 1.16 mm ($P = .65$) for the (−) and (+) PMD groups, respectively. Statistically significant differences were found before and after surgery ($P < .04$), but no significant differences were observed in PMD after orthodontic treatment.

Conclusions. SARPE led to a significant transverse expansion, and the dental effects were more than the skeletal effects. We did not find a significant difference between both surgical techniques with regard to the anterior and posterior parts of the maxilla or the corresponding dentition. (Oral Surg Oral Med Oral Pathol Oral Radiol 2020;130:241−251)

Surgically assisted rapid palatal expansion (SARPE) is one of the most common procedures in the treatment of adults with transverse maxillary deficiencies. Various osteotomy techniques for SARPE have been described. However, they weaken the bone structures to varying degrees.[1-5] The zygomatic buttress and the pterygomaxillary junction are regarded as the most rigid bone pillars of resistance.[6] The effect of the pterygomaxillary disjunction (PMD) has been explored. Some authors have proposed that a disjunction in almost all the maxilla bone pillars can allow for sufficient transverse expansion.[7-9] In contrast, others have reported that SARPE without pterygoid separation can decrease postoperative complications and morbidity.[10-14]

Koudstaal et al.[15] reported different patterns of expansion after SARPE without PMD. For example, the ratio of anterior-to-posterior expansion is higher in patients without pterygomaxillary disconnection than in patients receiving osteotomy for the disjunction of pterygoid plates.[15] Hamedi Sangsari et al.[16] conducted a systematic review and meta-analysis, which only included 3 articles and found that the current literature does not have enough information about the consequence of PMD performed during SARPE, so more studies are needed.

Zandi et al.[17] also investigated PMD in SARPE in a short-term controlled clinical trial using cone beam computed tomography (CBCT) and found a comparable amount of expansion in the first premolar and molar areas in treatment with or without PMD. Furthermore, they reported no statistically significant difference between both groups in the amount and pattern of maxillary expansion. They concluded that SARPE without PMD is recommended for the treatment of transverse maxillary deficiencies. However, Ferraro-Bezerra et al.[18] reported slight differences between both treatments in the patterns of skeletal and dental alterations. These investigations have compared the preoperative state and the expansion or retention period before orthodontic treatments begin.

Therefore, this study aimed to evaluate if PMD had long-term dentoalveolar effects after a subsequent orthodontic treatment. This study hypothesized that

Statement of Clinical Relevance

Pterygomaxillary disjunction in surgically assisted rapid palatal expansion did not influence orthodontic treatments and likely played a minor role in transverse expansion. Therefore, this procedure should be performed in selected cases to minimize the risk of surgical complications.

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slight differences in the skeletal and dental patterns of expansion after SARPE with PMD would not influence subsequent orthodontic treatments.

MATERIALS AND METHODS

Patients

This study was conducted in accordance with the tenets of the Declaration of Helsinki. The Ethics Committee of the Medical Faculty of the Rheinisch-Westfälische Technische Hochschule (Aachen, Germany) reviewed and approved the study protocol (No. EK089/16). Study models of 27 patients were examined retrospectively. The models included 18 females and 9 males (mean age 26.3 years; range 16.75−42.5 years), who were treated to correct transverse maxillary discrepancies between April 2014 and February 2019 in the Department of Orthodontics and Oral and Maxillofacial Surgery at the University Hospital of Rheinisch-Westfälische Technische Hochschule (Aachen, Germany). Group 1 consisted of 15 patients with (+) PMD (mean age 26.3 years; range 17.6−40 years). Group 2 comprised 12 patients without (−) PMD (mean age 26.3 years; range 16.8−42.5 years). Information about PMD was obtained from surgical reports or patients' files. For transverse expansion, a tooth-borne fixed hyrax-type palatal expansion screw appliance (Forestadent GmbH, Pforzheim, Germany) was used. The appliance was cemented on to the first premolar and first molar bands of teeth 1 day before surgery.

Surgical procedure, expander activation, and orthodontic treatment

Surgery under general anesthesia was performed by 2 surgeons. One surgeon carried out SARPE without PMD, and the other performed SARPE with PMD. In both groups, the operation started with an incision from the first molar to the midline on both sides of the maxillary vestibule for subperiosteal soft tissue reflection to the lateral wall of the maxilla. Next, the anterior floor of the nose and the piriform aperture area posterior to the pterygomaxillary fissure were exposed. Osteotomy was then performed from the piriform aperture through the zygomatic buttress to the pterygomaxillary connection. The nasal mucoperiosteum was lifted, the nasal septum was released, and thin Lambotte osteotome malleting was conducted between the roots of the upper central incisors through the midpalate suture. In group 2, PMD was performed by placing a malleting-curved pterygoid chisel between the tuberosity and the pterygoid plates. In both groups, the tooth-borne expander was turned by about 2 mm to verify the complete and symmetric expansion of the segments. The wound was closed with self-dissolving sutures. The patients were discharged from the hospital 2 to 3 days after the surgery and provided with antibiotic, anti-inflammatory, and analgesic drugs.

After a latency period of 3 to 7 days, a palatal expander screw was activated by about 0.75 mm on the first 3 days, followed by 0.50 mm per day until the target value was reached. Then, a hyrax screw was fixed with a ligature wire. Sutures were removed 10 days after surgery to prevent infection. Adequate wound healing was present at this time after all operations. The means of hyrax screw activation were 5.88 mm (standard deviation [SD] 0.77 mm) in the (−) PMD group and 5.65 mm (SD 1.85 mm) in the (+) PMD group. The apparatus was retained for an average of 6.78 months, followed by, on average, 24.6 months of orthodontic treatment with a fixed appliance (T1).

Measurements

The study casts before SARPE (T0) and after orthodontic treatment (T1) were transferred to a virtual reality setting by using digital scans generated by a 3-dimensional (3-D) model scanner (orthoX, Dentaurum, Ispringen, Germany), and STL (stereolithography) files were obtained. Impressions were carried out 10 days after the braces were removed to prevent incorrect measurements of the crown height through inflammatory gingival hyperplasia. Linear measurements on the study models were performed with software support (Blender, Amsterdam, Netherlands; Geomagic, Morrisville, NC) in accordance with Kilic et al.[19] 3-D measurements, as proposed by Möhlhenrich et al.,[20] were conducted, and the STL files were imported into the Geomagic Qualify software (Geomagic, Morrisville, NC). Pre- and postoperative study models were compared through automatic surface registration based on an iterative closest point algorithm. Then, deviations between the surfaces of the test and reference objects were determined. The plicae palatinae transversae and the incisive papilla of the anterior soft tissue of the palate were used as references for comparison. All the measurements were performed with software support by one of the investigators.

Linear and angular measurements. The maxillary dental arch width was measured between the vestibular (C.I, P1.I, P2.I) and palatal cusp tips (C.II, P1.II, P2.II) of the canine and the first and second premolars and between the mesiobuccal (M1.I, M2.I) and mesiopalatal cusp tips (M1.II, M2.II) of the first and second molars (Figure 1A). For evaluation of transverse asymmetry, the distance between the right side of the arch width and the raphe palatina line was measured and subtracted from the distance on the left side (Figure 1B). A negative difference meant that the distance of the teeth on the right side was greater, and vice versa. For symmetric ratios, the difference was 0.

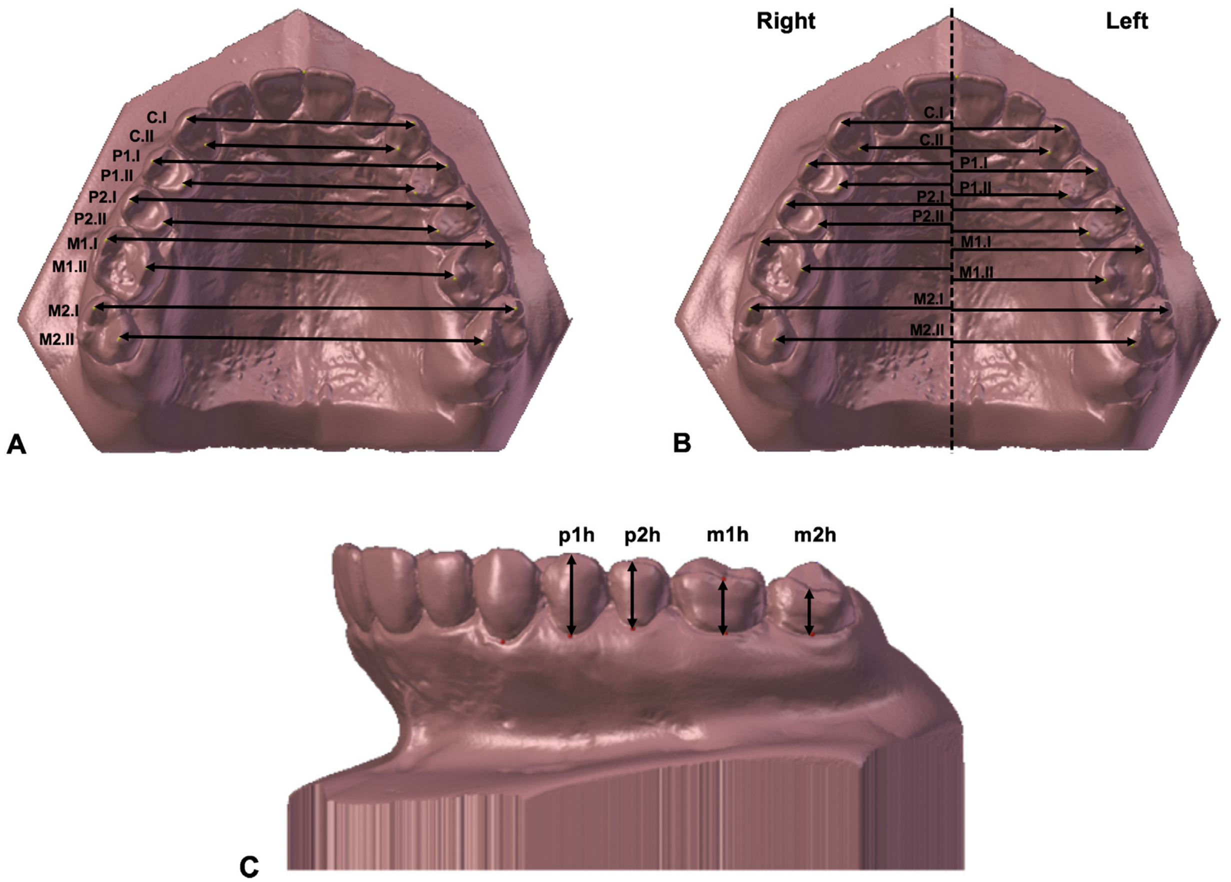


Fig. 1. Virtual linear measurements. **A,** Dental arch width. **B,** Transversal dental arch asymmetry. **C,** Clinical crown height.

The clinical crown heights of the first and second premolars (p1 h, p2 h) and the first and second molars (m1 h, m2 h) were measured vestibular, from the buccal cusp tip to the most apical point of the gingival margin (Figure 1C).

The palatal gingival depth (A) was taken as the shortest distance from the midpalate raphe to the connecting line between the gingival crests adjacent to the first molars. The palatal molar cusp depth (B) was measured as the shortest distance from the midpalate raphe to the connecting line between the occlusal surfaces of the first molars. The palatal gingival width (C) was measured between the palatal gingival crests of the first molars and the midpalate width (D) between the projected halfway points on the right and left palatal surfaces from the palatal gingival depth (Figure 2).

The palatal vault angle (α) was measured between the tangential lines to the middle two-thirds of the right and left palatal surfaces. The angle between the intersecting lines drawn across the mesial buccal and mesial lingual cusp tips of the right and left first molars was measured to determine the axial angulation of the maxillary first and second premolars and the first and second molars(β; see Figure 2).

3-D measurements. The wholly automated comparison between the study model surfaces generated a full-color deviation map and a histogram (Figure 3). In the color map overlay, the proximity of objects was shown in green, increased differences in the distance from the virtual simulation were presented in red, and decreased differences were illustrated in blue. The maximum deviations of the vestibular and palatal sides of the alveolar process below the first incisor, first premolar, and the first molar and the overall maximum deviation of the right and left alveolar ridges and hard palate were measured.

Statistical analysis

Statistical comparisons were performed by using GraphPad Prism v8 (GraphPad Software, San Diego, CA). The D'Agostino and Pearson test was applied to the data. Data, except the measured clinical crown height, were normally distributed, and the variance among the groups exhibited homogeneity. The t test was performed to compare the measurements before and after treatment and between both treatments. The significance level was set at $P \leq .05$. Results were expressed as mean ± SD.

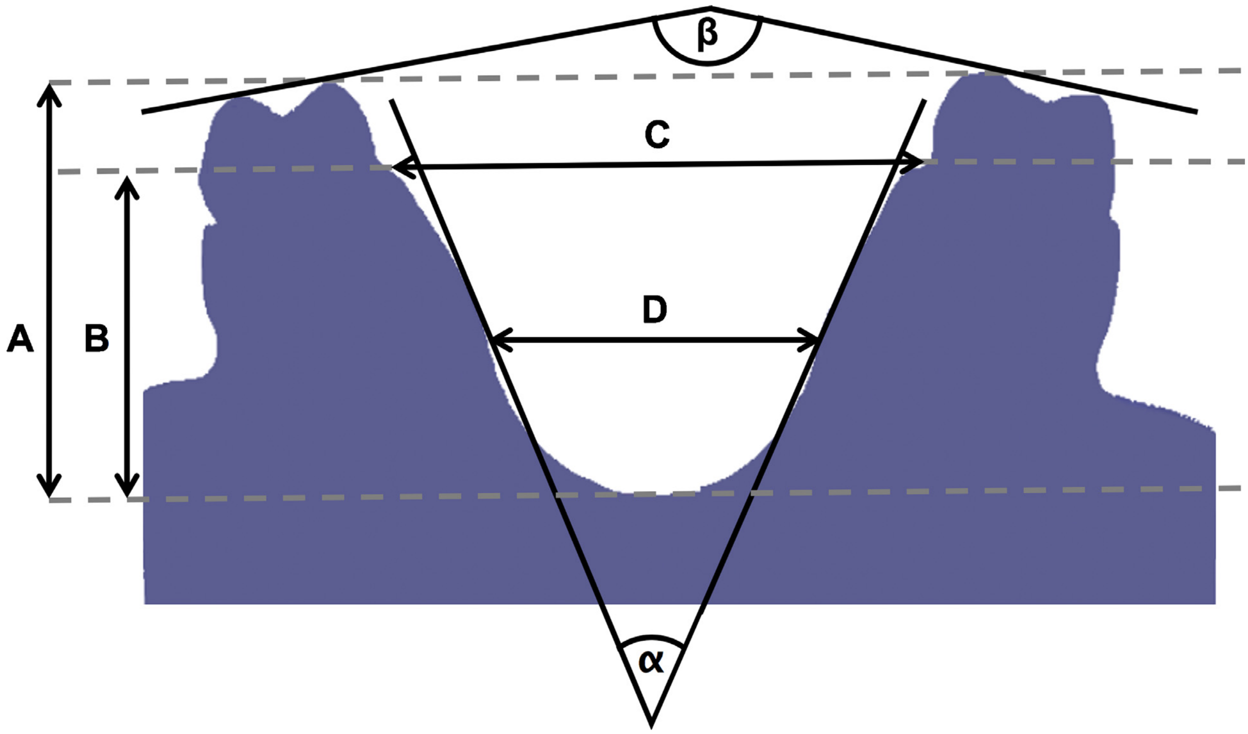


Fig. 2. Virtual linear and angular measurements in the transverse and vertical directions of the maxilla. **A,** Palatal gingival depth. **B,** Palatal molar cusp depth. **C,** Palatal gingival width. **D,** Midpalate width. **E,** Palatal vault angle. **F,** Tooth axial angulation.

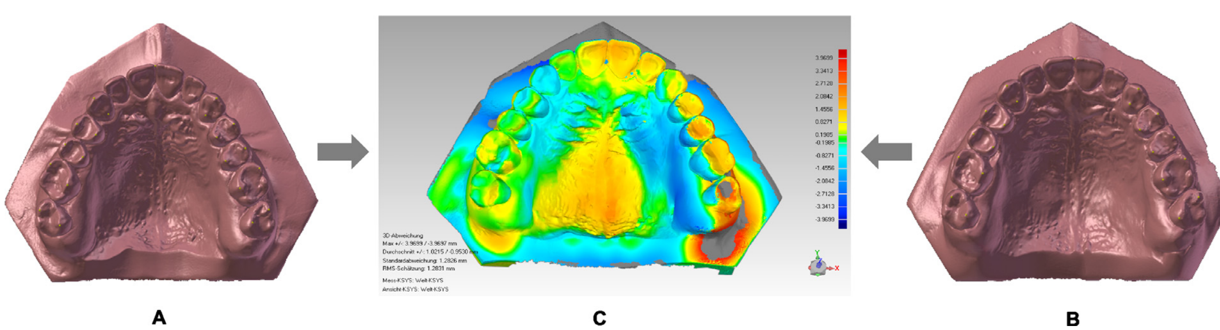


Fig. 3. Measurement process for the maximum changes in the alveolar ridge and hard palate. Virtual study model before **(A)** and after treatment **(B)** and after an automated superposition for creating a full-color deviation map **(C)**.

RESULTS

The pre- and post-treatment values of linear and angular measurements and the corresponding statistical comparisons within and between groups are presented in Table I. The comparisons between the mean changes (T1 − T0) after surgical and orthodontic treatments are shown in Figures 4A to 4E, and the comparison of the maximum deviation at the alveolar ridge and hard palate is illustrated in Figure 5.

Immediately after completion of the entire orthodontic and orthognathic treatments, all crossbites were successfully treated. Significant changes in the dental arch width were observed in all pre- and posttreatment transverse measurements. However, significant differences between both groups were only found before treatment for M1.II, M2.I, and M2.II and after treatment for P2.II, M1.II, M2.I, and M2.II (see Table I). No significant differences between both groups in the mean changes (T1−T0) were found (see Figure 4A).

The treatment led to a descriptive reduction of the transversal asymmetries of the dental arch in both groups. However, no significant differences in the expansion pattern were found (see Figure 4B).

An increase in crown height was measured in nearly all teeth in both groups, but this increase was not significant. This finding also applied to the underlying surgical procedure (see Table I).

Table I. Pre- and post-treatment values and statistical comparisons on SARPE with and without PMD and the time of treatment (before T0, and after T1)

		(−)PMD				*(+)PMD*				*Comparison (−)PMD versus (+)PMD*
		N	*Mean*	*SD*	*P value*	*N*	*Mean*	*SD*	*P value*	*P value*
C.I	T0	12	30.6	1.63	< .001*	15	30.86	2.46	< .001*	.779
	T1	12	34.5	1.40		15	34.43	2.63		.941
C.II	T0	12	24.7	1.89	< .001*	15	24.87	1.45	< .001*	.792
	T1	12	28.3	1.74		15	29.69	2.01		.071
P1.I	T0	12	37.3	2.11	< .001*	15	37.19	3.41	< .001*	.930
	T1	12	42.7	1.95		15	42.91	2.64		.862
P1.II	T0	12	26.9	2.17	< .001*	15	27.82	2.87	< .001*	.378
	T1	12	32.6	2.37		15	33.41	2.75		.404
P2.I	T0	10	40.8	2.30	< .001*	11	42.84	3.28	< .001*	.122
	T1	10	47.1	2.08		11	49.75	3.96		.073
P2.II	T0	10	30.2	2.22	< .001*	11	32.20	4.15	< .001*	.185
	T1	10	36.5	2.37		11	39.57	3.75		.039*
M1.I	T0	12	45.7	3.23	< .001*	15	47.99	3.99	< .001*	.119
	T1	12	51.8	3.40		15	54.10	3.73		.104
M1.II	T0	12	34.1	3.40	.002*	15	37.89	3.68	.002*	.010*
	T1	12	39.2	3.57		15	42.80	4.28		.029*
M2.I	T0	11	53.3	3.76	.04*	13	56.22	2.80	.001*	.042*
	T1	11	56.8	3.65		13	60.70	3.51		.014*
M2.II	T0	11	42.5	3.91	.10	13	45.40	2.89	.009*	.049*
	T1	11	45.3	3.83		13	49.55	4.43		.022*
Left p1 h	T0	12	7.38	1.40	.22	15	7.69	1.24	.59	.547
	T1	12	8.07	1.29		15	7.93	1.13		.764
Left p2 h	T0	11	6.15	0.67	.25	12	6.68	1.22	.82	.223
	T1	11	7.00	2.27		12	6.79	1.30		.792
Left m1 h	T0	12	5.28	0.59	.24	15	5.75	1.26	.74	.252
	T1	12	5.94	1.77		15	5.60	1.24		.562
Left m2 h	T0	12	5.48	0.60	.69	13	4.86	1.25	.97	.134
	T1	12	5.67	1.58		13	4.84	1.15		.144
Right p1 h	T0	12	7.36	0.89	.27	15	7.68	0.85	.79	.350
	T1	12	7.81	1.06		15	7.78	1.11		.932
Right p2 h	T0	10	6.03	1.08	.28	12	7.00	1.19	.54	.062
	T1	10	6.62	1.29		12	6.69	1.24		.901
Right m1 h	T0	12	5.61	0.69	.39	15	5.81	1.18	.93	.600
	T1	12	6.36	2.86		15	5.77	1.11		.475
Right m2 h	T0	11	5.10	0.64	.18	15	5.13	0.98	.85	.936
	T1	11	6.38	3.02		15	5.21	1.38		.196
A	T0	12	15.55	2.48	.71	15	13.94	2.40	.38	.099
	T1	12	15.22	1.95		15	13.16	2.39		.097
B	T0	12	21.36	2.63	.84	15	20.27	2.81	.46	.313
	T1	12	21.17	1.90		15	19.50	2.90		.024*
C	T0	12	29.38	2.95	< .001*	14	33.31	4.73	.004*	.020*
	T1	12	34.02	2.97		14	38.45	3.95		.004*
D	T0	12	16.03	1.63	.01*	15	17.15	5.13	.14	.475
	T1	12	18.42	2.44		15	19.96	5.01		.337
α	T0	12	47.75	15.4	.99	15	54.60	14.74	.78	.251
	T1	12	47.85	10.3		15	56.34	19.15		.179
β_{P1}	T0	12	166.59	13.32	.88	15	161.81	12.19	.77	.341
	T1	12	165.92	8.15		15	160.39	13.62		.227
β_{P2}	T0	10	170.29	6.04	.32	11	171.28	5.45	.89	.697
	T1	10	166.63	9.52		11	171.68	7.68		.195
β_{M1}	T0	12	161.36	18.51	.77	15	164.10	7.33	.23	.603
	T1	12	159.35	15.13		15	167.16	6.12		.079
β_{M2}	T0	11	150.71	12.84	.91	13	155.52	11.14	.81	.336
	T1	11	151.36	13.75		13	154.42	12.54		.575

*$P \leq .05$. *PMD,* pterygomaxillary disjunction; *SARPE,* surgically assisted rapid palatal expansion.

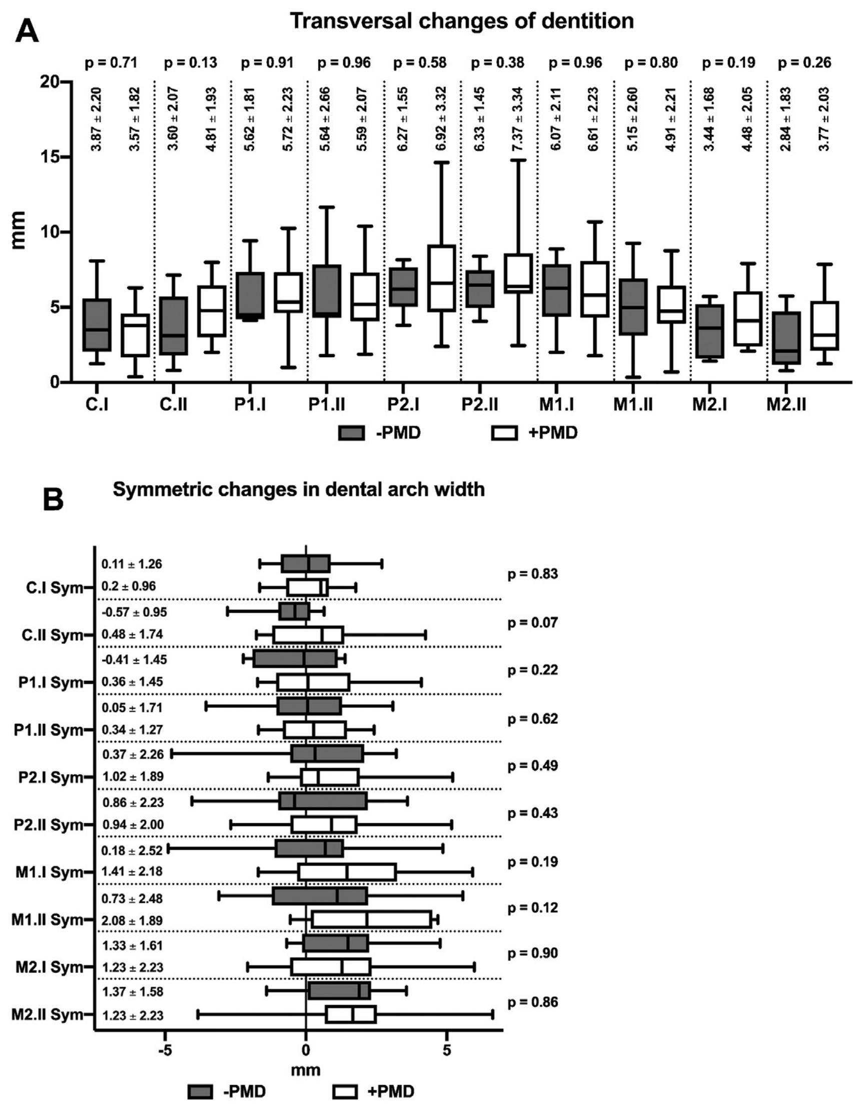


Fig. 4. Boxplots of the mean changes between pre- and post-treatment values and the statistical comparisons on surgically assisted rapid palatal expansion (SARPE) with and without pterygomaxillary disjunction (PMD). **A,** Transverse changes in the dental arch width. **B,** Symmetric changes in the dental arch width. **C,** Vertical changes in crown height. **D,** Transverse and vertical changes in the maxilla; statistical significance: $P \leq .05$.

However, the comparison between the mean changes in both groups demonstrated that the increase was less or negative in the group with PMD. In the case of the right p2 h, this increase was statistically significant (see Figure 4C).

With regard to changes in the maxilla, no differences were observed in the vertical measurements of the palatal gingival depth (A) and the palatal molar cusp depth (B). However, statistically significant differences in the pre- and post-treatment conditions were found in the palatal gingival width (C) and midpalate width (D). Significant differences were also observed between both surgical treatments (see Table I). No significant differences were detected in the treatment difference values (T1 − T0), although they were descriptively larger in the (+) PMD group than in the (−) PMD group (see Figure 4D).

Similarly, no changes could be detected in α and β within and between the groups (see Table I). This result also applied to the mean changes between the 2 groups (see Figure 4E).

The 3-D investigation demonstrated a decrease on the labial side of the alveolar ridge, in the anterior region of the first incisors and in the oral region of the first premolars and molars, and vice versa. The maximum deviations measured at the labial side of the alveolar ridge were about 3.04 mm (SD 0.76) for (−) PMD and about 3.22 mm (SD 1.16) for (+) PMD. However, only the difference in the mean overall changes on the oral side of the right alveolar ridge, that is, −1.96 mm (SD 0.72) for

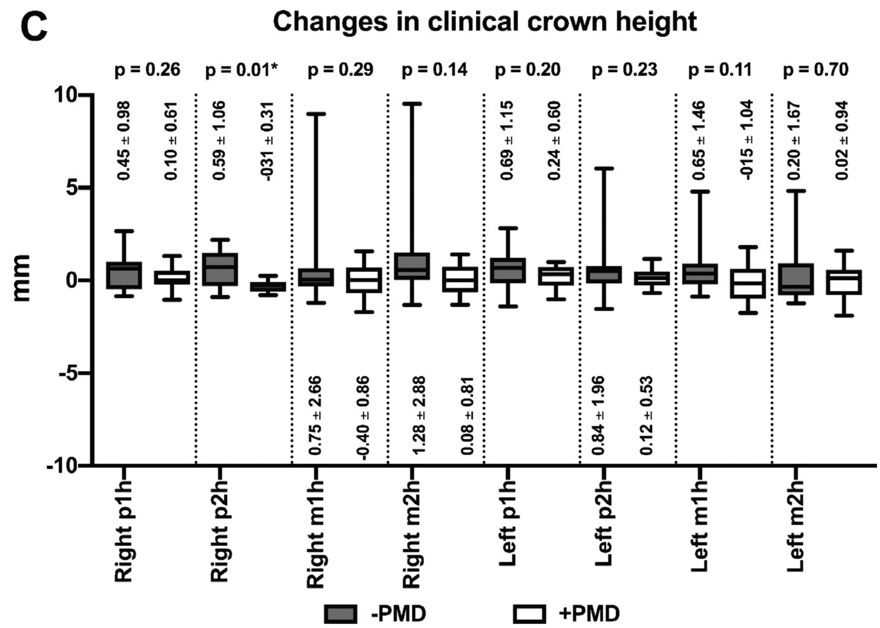


Fig. 4. Continued

(−) PMD and −2.69 mm (SD 1.02) for (+) PMD, was statistically significant. Almost no changes were measured in the hard palate, about −0.18 mm (SD 0.52) for (−) PMD and −0.07 mm (SD 0.26) for (+) PMD.

DISCUSSION

In SARPE, different resistance values in bones, such as the anterior piriform aperture pillars, lateral zygomatic buttresses, medial midpalate synostosis sutures, and posterior pterygoid junctions, have been considered[15,21] because of the challenge of finding a surgical technique with a reasonable risk of complications, uniform translational expansion of the maxilla, no treatment relapse, and no periodontal damage to teeth.[22,23]

The effect of the pterygoid processes is often discussed because PMD may lead to less bone resistance at the posterior maxilla, resulting in easy bone expansion,[7] and at the same time, the risk of complications is increased by more invasive procedures. In general, possible risks include dental discoloration, gingival recession, periodontal bone loss, loss of teeth, bleeding, hematoma, asymmetry, tissue necrosis, infections, hypoesthesia, subcutaneous emphysema, and inadequate expansion. However, major complications after SARPE are rare and include asymmetric or inadequate expansion and dental and/or periodontal problems primarily involving the central incisors.[24] In the current investigation, no major complications, such as bleeding, hematoma, tissue necrosis, or emphysema, were observed.

In a systematic review and meta-analysis of the effect of PMD during SARPE, Hamedi Sangsari et al.[16] reported that findings about the effects of PMD on SARPE outcomes are inconclusive. In 1 of their 3 articles, Vasconcelos et al.[25] investigated the cast models of patients with or without PMD and found no statistically significant differences in both study groups. Kilic et al.[19] reported no significant differences after maxillary expansion and PMD but recognized a tendency for greater posterior expansion in patients with pterygomaxillary disconnection. Sygouros et al.[26] retrospectively investigated dentoskeletal changes by using CBCT after SARPE with or without PMD and reported more pronounced buccal bending of the alveolar process and increased buccal tipping of the posterior teeth in the patient group without disjunction of the pterygoid plates, but this finding had no statistically significant difference. Therefore, they proposed that PMD should be recommended for patients with periodontal compromise.

Most studies focusing on this topic have investigated skeletal and dental changes at the end of the expansion or after the retention period before orthodontic treatments.[18,27] However, there are no reports of any investigation on the real effect of PMD on SARPE after orthodontic treatment. Therefore, this study aimed to evaluate and compare the models before and immediately after orthognathic surgery and orthodontic treatment to prevent influences from relapses caused, for example, by habits, the pressure of the soft tissue, or swallowing behavior.

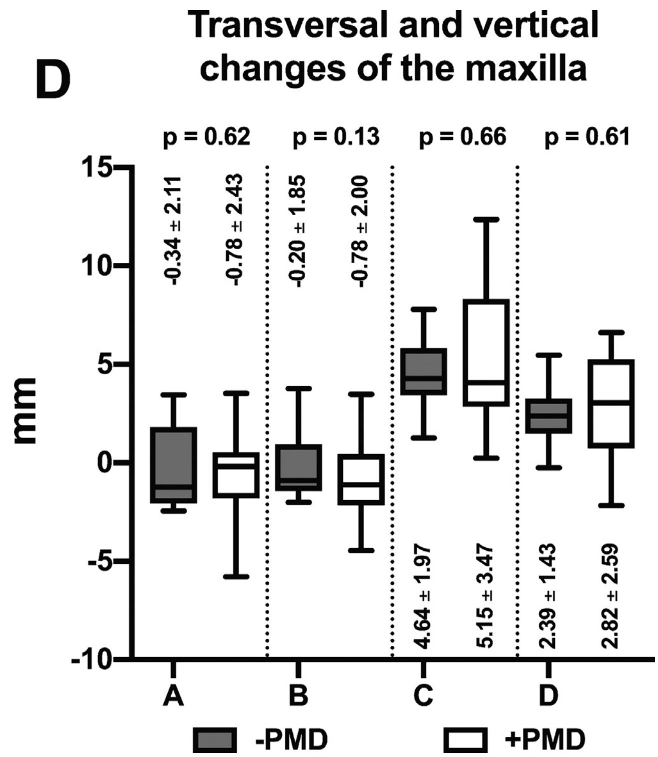


Fig. 4. Continued

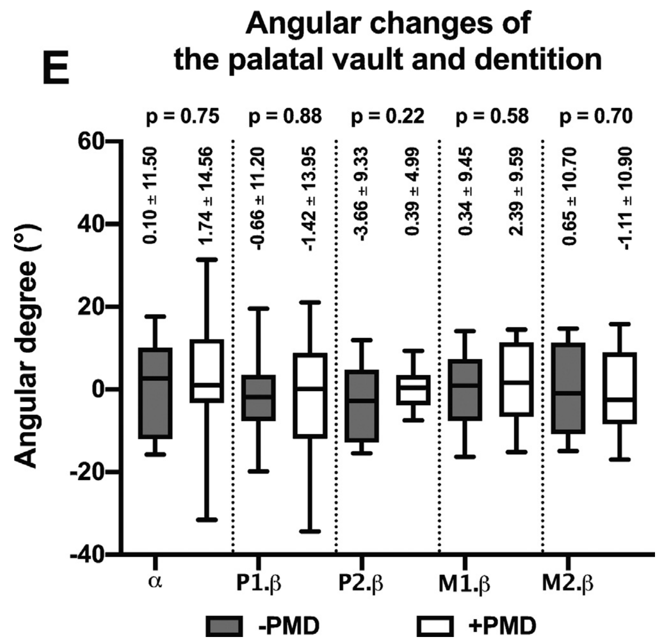
In this investigation, the study models were initially transferred to virtual 3-D models and subsequently evaluated by using 2 different computer programs. The linear and angle measurements were performed as proposed by Kilic et al.[19,28] The virtual superimpositions of the pre- and post-treatment study models were performed and analyzed in accordance with the findings of a previous investigation on this topic.[20]

Statistically significant differences between the groups before treatment (T0) were found in M1.II, M2. I, M2.II, and palatal gingival width (C). Thus, comparison of the baseline values of the groups was not entirely possible. Larger values in the (+) PMD group were determined in these measurements. Nevertheless, the average treatment difference values were determined to compare the changes in the groups.

A statistically significant difference between the pre- and post-treatment conditions within each group was found in terms of the transversal changes in the dental arch. As previously reported, both procedures led to a significant dentoalveolar expansion for crossbite treatment. However, no significant differences were found between the 2 groups. This result applied to all the transversal linear measurements. Indeed, the dental arch expansion was larger in the premolars and molars than in the canines. This finding was also found in other studies, immediately after expansion as well as after the retention period.[3,13,19,29] In this context, other studies have shown that the expansion in the first molar region is about 1 mm greater in the (−) PMD group than in the (+) PMD group, but this value is not significantly different from that in the (+) PMD group.[18,19,29,30] In the present study, the arch width was only greater between the second premolars and the molars in the (+) PMD group than in the (−) PMD group, but no significant difference between their arch widths was observed.

In terms of the symmetry of the dental arch, the distance of the teeth on the right side was greater before treatment than that after treatment in both groups. After treatment, the symmetry improved in both groups. Asymmetry increased from the anterior part to the posterior part. The treatment difference values (T1 − T0) increased transversely in both groups, but no significant differences were found. In postorthodontic treatment, significant differences were only observed in the right M1.I. Therefore, the transversal correction of the dental arch was equal in both groups.

Sygouros et al.[26] evaluated the periodontal effects of both SARPE techniques by measuring the width of the buccal alveolar bone covering the posterior teeth and the canines on a previously defined dentoalveolar level and the height of the alveolar crest. They observed that the width of the buccal alveolar bone in all of the posterior teeth decreased in both groups, but this decrease was not



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statistically significant in the region of the canines in the (−) PMD group. Furthermore, the loss of the buccal alveolar bone in the premolar area after SARPE without PMD was larger than that after SARPE with PMD. Sygouros et al. reported that the alveolar crest height decreased to a greater extent in the premolars of the (−) PMD group than in the premolars of the (+) PMD group, but the intergroup difference did not reach statistical significance. Gauthier et al.[23] also reported similar periodontal measurements. The crown height of all of the premolars and of the molars increased, but this increase was significant only in the first premolars of the (−) PMD group. The increase in the anatomic crown height was not significantly different between the groups. Nevertheless, periodontal support is compromised in SARPE without PMD.[26]

In the present study, the clinical crown in both surgical groups increased to varying degrees, but no statistically significant difference was observed. This finding also applied to the different treatment values. However, the increase was greater after SARPE without PMD than after SARPE with PMD. Kiliac et al.[19] reported similar results after the retention period. This finding could indicate that more recession could be expected in patients without PMD, even though no statistically significant difference was observed.

Considering the changes in the alveolar ridge and the hard palate, we did not observe any changes in the palatal vault angle or axial angulation of the premolars and the molars within and between the 2 groups or the changes in their means. In contrast, Kilic et al. found an increase in the palatal vault angle of 11.25 SD 7.42 degrees in the (+) PMD group and 8.60 SD 4.55 degrees in the (−) PMD and a decrease in the molar inclination of −7.25 SD 4.77 degrees in the (+) PMD group and even −18.50 SD 17.49 degrees in the (−) PMD. These results suggested that the tipping is low, that is, about 11.25 degrees, after (+) PMD. Their findings were comparable with those of Kurt et al.,[31] who demonstrated that expansion after SARPE is mainly a lateral rotation of the 2 maxillary segments. Sygouros et al.[26] observed that buccal alveolar bending and buccal tipping of the posterior teeth are more pronounced when transverse expansion is performed after SARPE without PMD than when it is performed after SARPE with PMD, even though the difference is not statistically significant. Our results revealed that subsequent orthodontic treatment compensated for the postoperative differences described in previous studies.

In this context, our findings demonstrated that the changes in the alveolar ridge and the hard palate before and after treatment were only significant within and between both groups in terms of the palatal gingival width and before and after treatment for the palatal midpalate width in the (−) PMD group. No significant differences were noted in the vertical dimension of the palatal gingival depth or the palatal molar cusp depth in all the groups and comparisons. In contrast, Kiliac et al.[19] reported a significant increase in these measurements in the (−) PMD group but not in the (+) PMD group after the retention period. Furthermore, they observed no

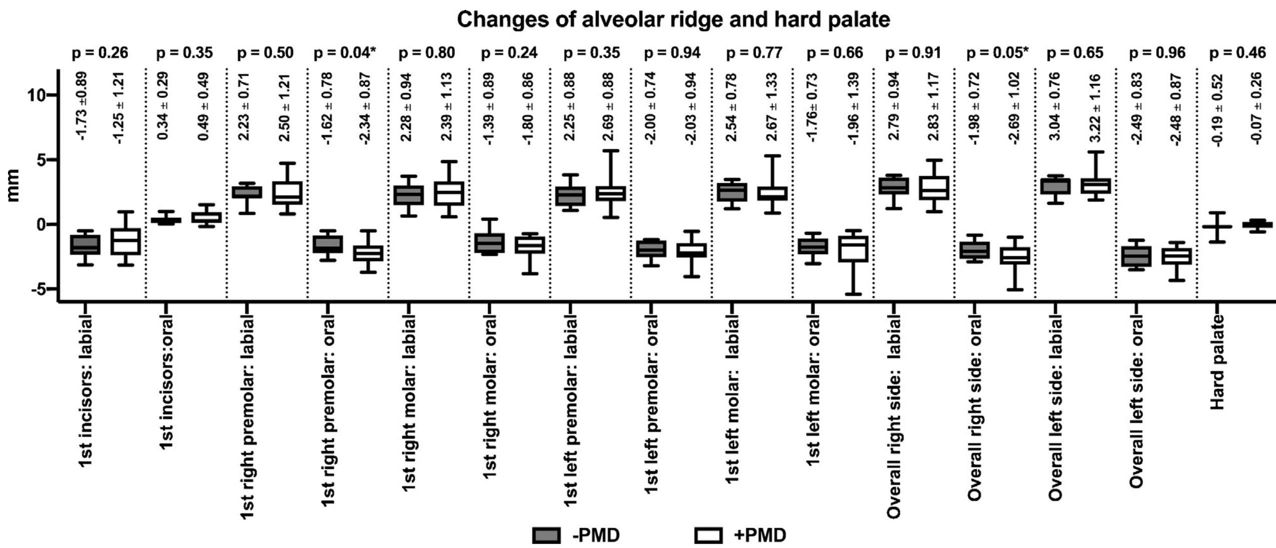

Fig. 5. Mean maximum changes in the alveolar ridge and the hard palate and the corresponding statistical comparisons on surgically assisted rapid palatal expansion (SARPE) with and without pterygomaxillary disjunction (PMD); statistical significance: $P \leq .05$.

significant alterations in the treatment difference values between both surgical techniques. This result suggested that a permanent skeletal transformation of the alveolar ridge and the hard palate occurred only in the palatal gingival width.

Ferraro-Bezerra et al.,[18] in their blinded randomized clinical trial, observed that a uniform median palatine suture opening and a V-shaped palatine suture opening may be obtained through SARPE with PMD and without PMD, respectively. Goldenberg et al. and Loddi et al.[22,32] demonstrated greater bone expansion in the anterior palate after SARPE without PMD or a more parallel opening pattern with PMD compared with that after SARPE with PMD. Therefore, the anterior opening of the median palatine suture increases when PMD is not used, possibly because the expander has less bone resistance in this region. This consideration seems justified by the results of Möhlhenrich et al.,[33] who observed that the bone pillar of the facial skeleton further weakens, leading to a decrease in stress distribution in the midface and a more lateral transverse expansion of the maxilla. In the present study, the median palatine suture could not be examined directly because only situation models were evaluated. However, the superimposition of the models enables the prediction of skeletal changes.[20] Thus, similar changes in the labial and lingual sides of the maxillary alveolar ridge in premolar and molar regions could be determined. Bone remodeling could also occur during orthodontic treatment, and potential skeletal differences caused by PMD would dissolve.

CONCLUSIONS

The controversial effect of PMD in SARPE has no importance when subsequent orthodontic treatment is considered. Orthodontic therapy likely compensates for slight dentoalveolar differences in the outcomes of both surgical techniques. As such, SARPE should be performed without PMD to minimize the risk of major surgical complications, even though they are rare. Furthermore, it must be considered that the present report does not provide any long-term data regarding possible relapse of crossbite, depending on the PMD effect. In selected cases, such as extreme transverse discrepancy of the maxilla, it could be useful to disregard this recommendation.

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