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Dental tipping and rotation immediately after surgically assisted rapid palatal expansion

Chun-Hsi Chung and Adena M. Goldman
Department of Orthodontics, School of Dental Medicine, University of Pennsylvania, Philadelphia, USA

SUMMARY The purpose of this investigation was to evaluate the effects of dental tipping and rotation immediately after surgically assisted rapid palatal expansion (SARPE). Fourteen patients (10 females, four males; mean age 25.6 years) who required a SARPE procedure were available for this study. A palatal expander appliance was cemented on four abutment teeth (first premolars and first molars) of each patient 1 week prior to surgery. Maxillary study models were taken before surgery and 2–3 weeks after full expansion (7 mm). Each model was trimmed to have the base parallel to its occlusal plane. From an occlusal view, measurements were made to determine if the abutment teeth underwent rotation from SARPE. From a postero-anterior view, the abutment teeth were examined for any tipping effect due to SARPE.

The results showed that from pre- to post-expansion, the two first premolars displayed 2.32 ± 8.29 degrees of mesiobuccal rotation ($P > 0.05$) and the two first molars displayed 3.09 ± 5.89 degrees of mesiobuccal rotation ($P > 0.05$). Each first premolar showed 6.48 ± 2.29 degrees of buccal tipping ($P < 0.05$) and each first molar 7.04 ± 4.58 degrees of buccal tipping ($P < 0.05$). SARPE induced a slight mesiobuccal rotation ($P > 0.05$) and significant buccal tipping of the first premolars and the first molars ($P < 0.05$). Some overexpansion is suggested to counteract the relapse effect of buccal tipping of the posterior teeth that takes place during SARPE.

Introduction

Orthopaedic rapid palatal expansion (RPE) has been used routinely in children to widen the maxilla and correct transverse discrepancies between the upper and lower arches. The rationale is that the orthopaedic force exerted from the expander can open the mid-palatal suture, which is usually patent in young children, and thus the maxilla is expanded (Haas, 1970). In adults or skeletally mature adolescents where the mid-palatal suture has fused and there is additional resistance from the circummaxillary sutures, RPE is often achieved in augmentation with a Le Fort I osteotomy with a mid-palatal cut (Kennedy *et al.*, 1976; Bell, 1982; Betts *et al.*, 1995). Nowadays, surgically assisted RPE (SARPE) has become a popular treatment modality as the number of adults seeking orthodontic treatment has increased significantly.

After the maxilla is expanded by orthopaedic RPE or SARPE, would the abutment teeth change their inclination (buccal or lingual tipping) or occlusal orientation (rotation)? There have been studies trying to answer this question. Ladner and Muhl (1995) reported, in 30 patients with an average age of 11.8 years, 4.6 ± 11.3 degrees of lingual tipping and 16.5 ± 15.4 degrees of mesiobuccal rotation at the first molars utilizing the orthopaedic RPE. However, in their study, the post-expansion models used to measure the tipping or rotation were taken after orthodontic treatment, not immediately following RPE. On the other hand, Ciambotti *et al.* (2001) found 6.08 ± 6.25 degrees of buccal tipping and 1.58 ± 2.74 degrees of mesiobuccal rotation at the first molars using orthopaedic RPE in 12 patients with an average age of 11.1 years.

In terms of dental tipping or rotational effects resulting from SARPE, Kuo and Will (1990) evaluated the postero-anterior (PA) cephalograms of 21 patients and found that the mean maxillary skeletal expansion from the expansion procedure was 84 per cent of the mean molar expansion, with a wide range. Thus, they suggested that there was some tipping effect on the molars with this expansion. Northway and Meade (1997) evaluated the dental tipping effects resulting from SARPE and a full course of edgewise orthodontic treatment. They reported nearly 5 degrees of buccal tipping at the first premolars and approximately 3 degrees of lingual tipping at the first molars in the buccal corticotomy with mid-palatal split group. However, they also stressed that much of the tipping from SARPE may be eliminated or reduced as a result of the following edgewise orthodontics. Similarly, Bays and Greco (1992) examined the dental tipping effects from SARPE followed by orthodontic treatment. They were unable to reach any conclusion because of the significant variation between patients. No reports regarding the effects of dental rotation from SARPE are available in the literature.

The purpose of this investigation was to evaluate the dental tipping and rotation effects on the abutment teeth of a palatal expander (first premolars and first molars) immediately after SARPE.

Subjects and methods

Subjects

Fourteen patients (10 females and four males) from two private practices and the Orthodontic Clinic of the University of Pennsylvania who required a SARPE procedure were available for this study. The mean age of the patients was 25.6 years, ranging from 14 to 46 years.

Pre-treatment (T1) study models were taken for all patients. One week before the scheduled SARPE procedure, each patient had a palatal expansion appliance with a 7 mm jackscrew (Figure 1) cemented on four abutment teeth (maxillary first premolars and first molars). All palatal expanders were made at the same orthodontic laboratory.

Three surgeons, using a similar technique, performed the surgery on all the patients. Essentially, the technique consisted of a subtotal Le Fort I osteotomy and a mid-palatal cut, as reported by Betts *et al*. (1995).

After surgery, the patients were instructed to activate the palatal expander two turns (0.25 mm expansion each turn) per day until the jackscrew was fully opened (7 mm). The expander was then inactivated by tying off the jackscrew with ligature wire or self-cure acrylic. Post-expansion (T2) maxillary study models were obtained for all patients 2–3 weeks later. All the impressions were taken with alginate and none of them showed any distortion. From T1 to T2, no brackets or wires were placed in the maxillary dentition and none of the teeth had any occlusal adjustment.

Study models

For each T1 and T2 maxillary model, the base was trimmed with a model trimmer (Great Lakes Orthodontics, Tonawanda, New York, USA) to parallel its occlusal plane. The occlusal plane was registered at the incisal edge of the right central incisor and the central occlusal fossa of the right and left first molars.

On each T1 model, a 0.020 inch stainless steel wire, approximately 2–3 cm in length, was fixed from the buccal cusp tip to the lingual cusp tip of each first premolar, and from the mesiobuccal (or distobuccal) cusp tip to the mesiolingual (or distolingual) cusp tip of each first molar using Weldabond glue (Frank T. Ross & Sons, Inc., Toronto, Ontario, Canada). On each T2 model of the same patient, the stainless steel wire was fixed on the same cusp tips of the same teeth as the T1 model (Figure 2).

Measurement of dental rotation (Figure 2)

For each model, a photograph was taken from above (occlusal view) using a camera with its lens parallel to

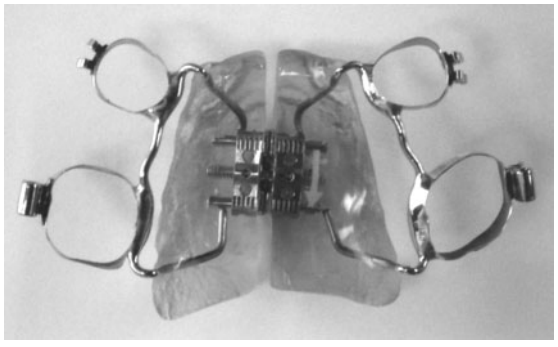

Figure 1 Illustration of the palatal expansion appliance. The appliance includes a jackscrew, a lingual bar, and an acrylic palate.

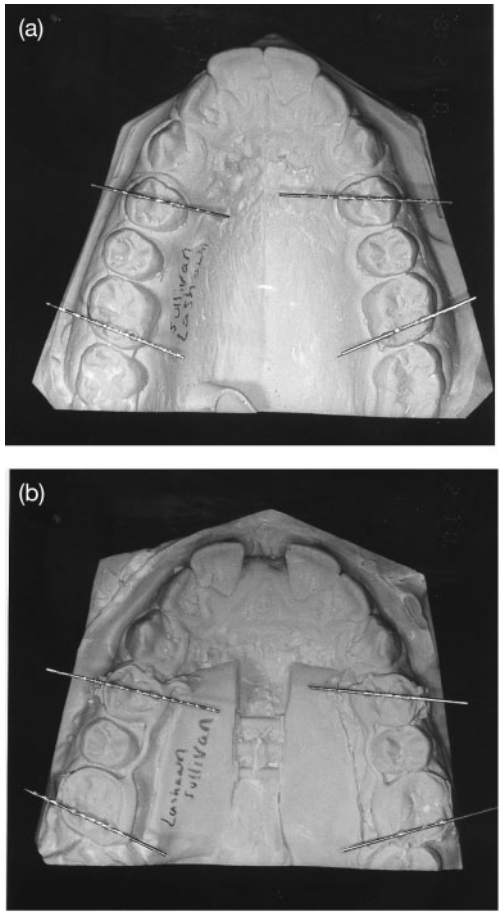

Figure 2 Measurements of rotation of the first premolars and first molars from pre- (T1, a) to post-expansion (T2, b). The wire lines on the premolars (or molars) were extended to intersect each other to form an angle (occlusal angle). The rotational effect from T1 to T2 for both premolars (or molars) was determined by subtraction of the T2 occlusal angle from the T1 occlusal angle of premolars (or molars).

the occlusal plane. On each picture, the wire lines on the first premolars were extended to intersect each other to form an angle (occlusal premolar angle). Similarly, an angle was formed by extending the wire lines on the first molars (occlusal molar angle). Each premolar or molar occlusal angle was measured by two examiners independently and an average was calculated. The rotational effect from T1 to T2 for the two first premolars (or molars) was determined by the subtraction of the T2 occlusal premolar (or molar) angle from the T1 occlusal premolar (or molar) angle. An increase in the occlusal premolar or molar angle from T1 to T2 was defined as positive (+) and mesiobuccal rotation, whereas a decrease in the angles was defined as negative (–) and mesiolingual rotation.

Measurement of dental tipping (Figures 3 and 4)

After the dental rotations from T1 to T2 were determined, each model was sectioned along the mid-palatal line using a laboratory stone cutting saw (J. M. Ney Co., Bloomfield, Connecticut, USA) into two halves (left and right). Each half was trimmed from the back towards the first molar (90 degrees to the base and parallel to the molar wire) until it was 0.5–1 mm short of the molar wire. The same half was then trimmed from the front (incisor region) towards the first premolar (90 degrees to the base and parallel to the premolar wire) until it was 0.5–1 mm short of the premolar wire. On this trimmed half model, an image was taken with a laser photocopying machine of the first premolar and the first molar so that the wire line of the first premolar and the first molar, and the model base were clearly shown on the photograph. On each photograph, the wire line of the first premolar or the first molar was extended to intersect with the model baseline and thus an angle was formed (inclination angle). Each inclination angle was measured by both investigators independently and an average was calculated. The tipping effect from T1 to T2 was determined by the subtraction of the T2 inclination angle from the T1 inclination angle of each abutment tooth. An increase in the inclination angle from T1 to T2 was defined as

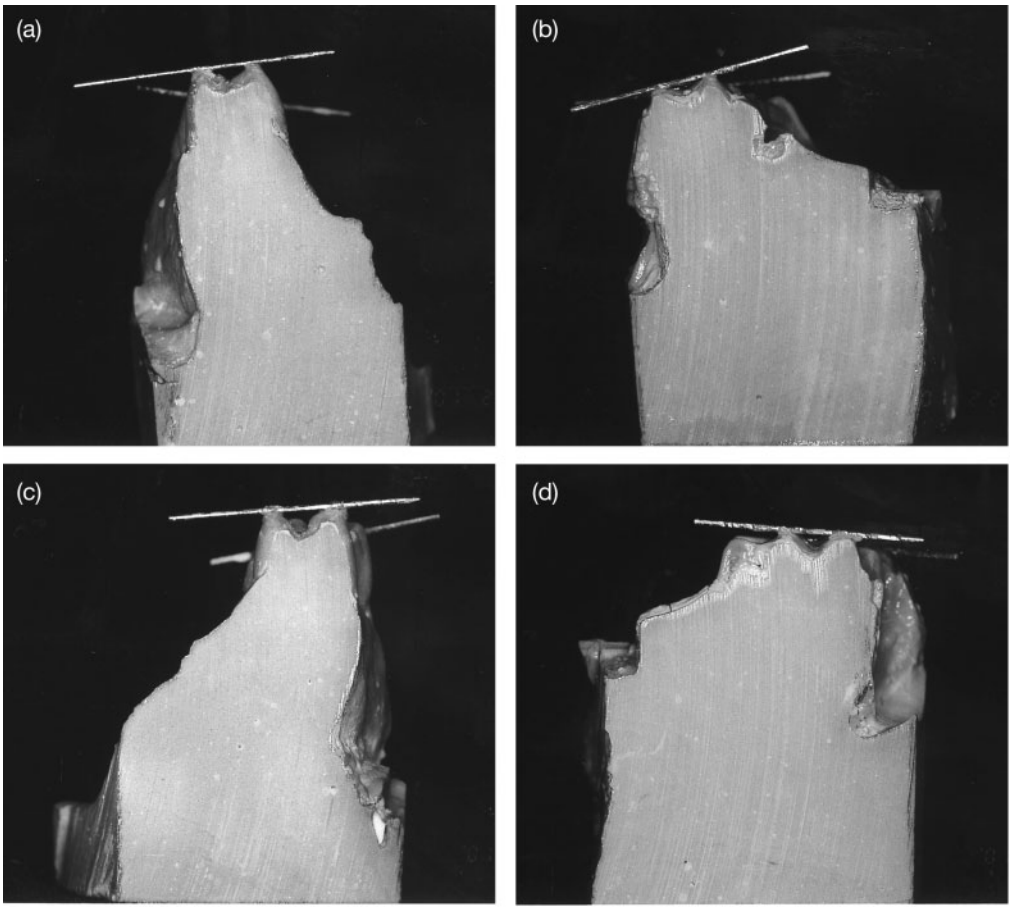

Figure 3 Measurements of tipping of each first premolar from pre- (T1) to post-expansion (T2). (a) Left premolar T1; (b) left premolar T2; (c) right premolar T1; (d) right premolar T2. The wire line of the first premolar was extended to intersect with the model baseline to form an angle (inclination angle). The tipping effect from T1 to T2 was determined by subtraction of the T2 inclination angle from the T1 inclination angle of each tooth.

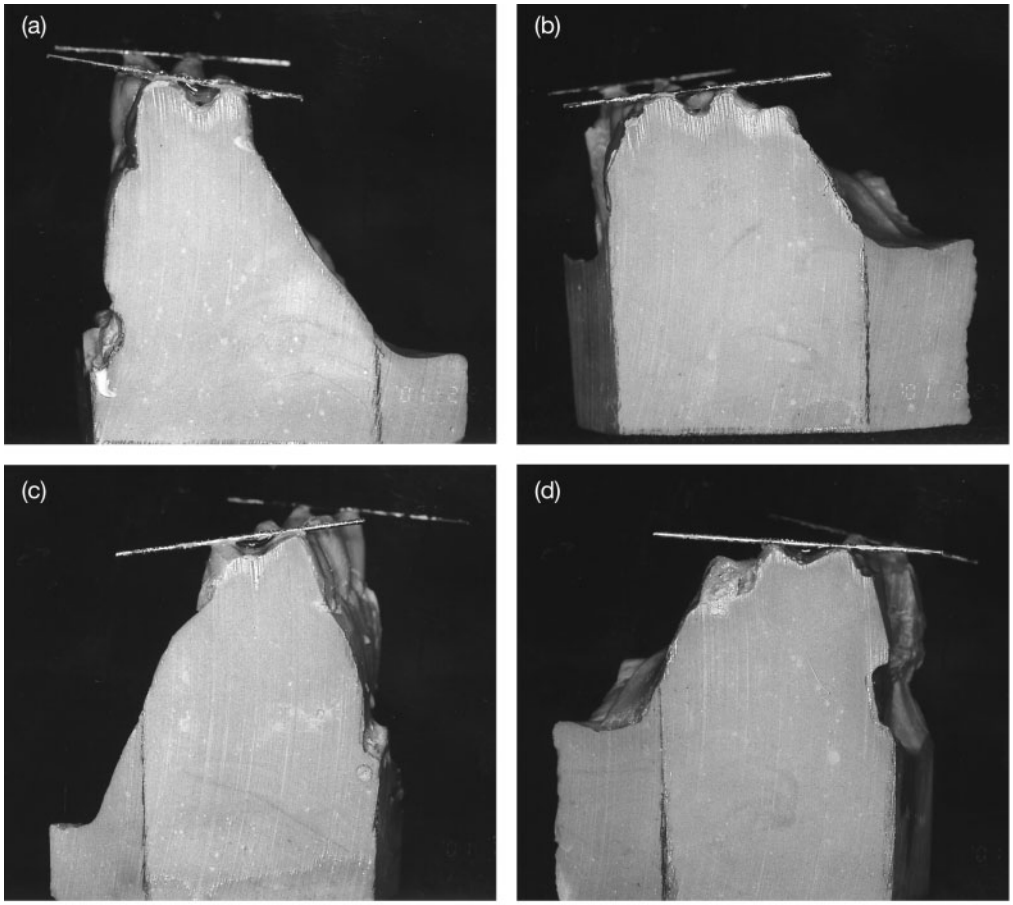

Figure 4 Measurements of tipping of each first molar from pre- (T1) to post-expansion (T2). (a) Right molar T1; (b) right molar T2; (c) left molar T1; (d) left molar T2. The wire line of the first molar was extended to intersect with the model baseline to form an angle (inclination angle). The tipping effect from T1 to T2 was determined by subtraction of the T2 inclination angle from the T1 inclination angle of each tooth.

positive (+) and lingual tipping, whereas a decrease in the inclination angle was defined as negative (–) and buccal tipping.

Statistical analysis

Descriptive statistical analyses, including the mean and standard deviation, were calculated for all measurements. A Student's paired *t*-test was used to determine if there was any significant difference in the angular measurements between the two examiners (inter-examiner reliability test), and if the tipping and rotation changes from pre- to post-expansion were statistically significant. Significance for all statistical tests was predetermined at $P < 0.05$.

Results

The inter-examiner reliability test showed no statistically significant difference in the measurement of the degree of tipping and rotation between the two examiners ($P = 0.95$).

Dental rotation measurements

Table 1 shows the rotation of the two first premolars and the two first molars from T1 to T2. Compared with the pre-expansion models, the post-expansion premolars displayed a mean of 2.32 ± 8.29 degrees of mesiobuccal rotation ($P > 0.05$). Similarly, the post-expansion two first molars displayed a mean of 3.09 ± 5.89 degrees of mesiobuccal rotation resulting from SARPE ($P > 0.05$). No statistically significant differences in rotation from T1 to T2 were found between the first premolars and the first molars.

Dental tipping measurements

Table 2 shows the changes in the inclination (tipping) of each first premolar and first molar and an average of both premolars and molars from T1 to T2. The left first premolar displayed 6.31 ± 3.17 degrees of buccal tipping ($P < 0.05$) and the right first premolar displayed 6.64 ± 4.64 degrees of buccal tipping ($P < 0.05$). The average buccal tipping of the left and right first

Table 1 Effects of rotation on both maxillary first premolars and maxillary first molars from pre- (T1) to post-surgically assisted rapid palatal expansion (T2).

Abutment tooth	*n*	Changes in occlusal angle from T1 to T2 (degrees)	SD (degrees)	Range (degrees)	Significance
Both first premolars	14	+2.32	8.29	–17.2 to +16.5	NS
Both first molars	14	+3.09	5.89	–15.8 to +6.5	NS

SD, standard deviation; NS, not statistically significant, $P > 0.05$.
A positive change indicates mesiobuccal rotation and a negative change indicates mesiolingual rotation.

Table 2 Changes in inclination (tipping) of each abutment tooth from pre- (T1) to post-surgically assisted rapid palatal expansion (T2).

Abutment tooth	*n*	Changes in inclination angle from T1 to T2 (degrees)	SD (degrees)	Range (degrees)	Significance
Left first premolar	14	–6.31	3.17	–12.3 to –1.5	*
Right first premolar	14	–6.64	4.64	–17.5 to –0.3	*
Averaged premolar	14	–6.48	2.29	–10.1 to –2.7	*
Left first molar	14	–7.94	3.88	–14.0 to –2.6	*
Right first molar	14	–6.14	6.15	–18.1 to +3.3	*
Averaged molar	14	–7.04	4.58	–16.1 to –1.6	*

SD, standard deviation.
*Statistically significant, $P < 0.05$.
A positive change indicates lingual tipping and a negative change indicates buccal tipping.
There was no significant difference in tipping between right and left premolars, right and left molars, premolars and molars ($P > 0.05$).

premolars from T1 to T2 was 6.48 ± 2.29 degrees ($P < 0.05$). The left first molar displayed 7.94 ± 3.88 degrees of buccal tipping ($P < 0.05$) and the right first molar 6.14 ± 6.15 degrees of buccal tipping ($P < 0.05$). The average buccal tipping of the left and right first molars from T1 to T2 was 7.04 ± 4.58 degrees ($P < 0.05$). When the left and the right sides and also the premolars and the molars were compared, no significant differences were found ($P > 0.05$).

Discussion

These results clearly show that there was significant buccal tipping of the first premolars and the first molars immediately after SARPE (each first premolar tipped by 6.48 degrees, $P < 0.05$ and each first molar by 7.04 degrees, $P < 0.05$). The data are similar to a previous study by Kuo and Will (1990), who examined PA cephalograms of 21 patients and found more intermolar expansion than maxillary skeletal width expansion resulting from RPE in conjunction with a modified lateral maxillary corticotomy. They suggested that the difference was due to molar buccal tipping. The present results cannot be compared with the findings of Northway and Meade (1997), who examined the study models of 15 patients and found 5 degrees of buccal tipping at the first premolars and 3 degrees of lingual tipping at the first molars after SARPE and full edgewise orthodontic treatment. The reason is that their post-expansion models were taken after orthodontic treatment and in the present investigation they were taken 2–3 weeks after SARPE.

A slight mesiobuccal rotation on the abutment teeth was found after SARPE (2.32 degrees for the two first premolars and 3.09 degrees for the two first molars). Although the amount of rotation was not statistically significant ($P > 0.05$), a large standard deviation (± 8.29 degrees for the premolars and ± 5.89 degrees for the molars) and a wide range (–17.2 to +16.5 degrees for the premolars and –15.8 to +6.5 degrees for the molars) was present, which might be due to the small sample size ($n = 14$). Thus, it would be difficult to draw a conclusion on the effects of dental rotation. A larger sample size would be needed to answer this question. To our knowledge, this is the first report of dental rotation resulting from SARPE, although a study evaluating the dental rotational changes after orthopaedic RPE has been reported (Ciambotti *et al*., 2001).

The T1 and T2 models of each patient were trimmed with their bases parallel to the occlusal plane, which was registered at the incisal edge of the central incisor and the central occlusal fossa of the right and left first molars. It should be noted that there might have been some minor changes in the occlusal plane resulting from SARPE. This limitation may have affected the inclination readings of individual right or left abutment

teeth. However, it should have minimal effects on the average of the inclination readings of the left and right individual abutment teeth. This is the reason why the average inclination measurements for both the right and left first premolars and molars are provided.

PA cephalograms have been used by other investigators to evaluate the dental tipping effects from maxillary expansion devices (Kuo and Will, 1990; Asanza *et al*., 1996). In the present study, models were used because it is difficult to locate and trace the first molars and first premolars precisely with PA cephalograms, as there is much overlapping of anatomical structures.

The inclination angle of each first premolar and first molar was measured separately instead of the angle of intersection of the lines drawn through the mesiobuccal and mesiolingual cusp tips of both the first molars or the first premolars together, as suggested by McNamara and Brudon (1993). The reason is that the cusp tips of the two first premolars and the two first molars are often not on the same plane due to rotation (this can be demonstrated by the formation of the occlusal premolar angle or occlusal molar angle). Thus, from the PA view, the angle of intersection of cusp tips cannot represent the inclination of the two teeth. This is why each cast was sectioned into two halves, each half trimmed to the abutment tooth and the inclination angle of each abutment tooth measured.

Orthopaedic expansion has been suggested to overexpand to the point where the lingual cusps of the upper posterior teeth are in contact with the buccal cusps of the lower posterior teeth, due to the relapse potential after appliance removal (Krebs, 1964; Haas, 1973). However, for SARPE, Kraut (1984) suggested that only 1.0–1.5 mm of extra expansion be accomplished, as surgically assisted expansions are stable. The results of this investigation showed significant buccal tipping at the first premolars and molars after SARPE, which may tend to relapse. Thus, some overexpansion may be necessary. Further studies are needed to determine the amount of overexpansion that is required with SARPE.

Conclusions

1. There was a slight mesiobuccal rotation of the maxillary first premolars and first molars resulting from SARPE ($P > 0.05$).
2. SARPE induced significant buccal tipping of the maxillary first premolars and first molars ($P < 0.05$).
3. Some overexpansion is suggested to counteract the relapse effect of buccal tipping of the posterior teeth that takes place during SARPE.

Address for correspondence

Chun-Hsi Chung
Department of Orthodontics
School of Dental Medicine
University of Pennsylvania
4001 Spruce Street
Philadelphia, PA 19104–6003
USA

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References

Asanza S, Cisneros G J, Nieberg L G 1996 Comparison of Hyrax and bonded expansion appliances. Angle Orthodontist 67: 15–22

Bays R A, Greco J M 1992 Surgically assisted rapid palatal expansion: an outpatient technique with long-term stability. Journal of Oral and Maxillofacial Surgery 50: 110–113

Bell R 1982 A review of maxillary expansion in relation to rate of expansion and patient's age. American Journal of Orthodontics 81: 32–37

Betts N J, Vanarsdall R L, Barber H D, Higgins-Barber K, Fonseca R J 1995 Diagnosis and treatment of transverse maxillary deficiency. International Journal of Adult Orthodontics and Orthognathic Surgery 10: 75–96

Ciambotti C, Ngan P, Durkee M, Kohli K, Kim H 2001 A comparison of dental and dentoalveolar changes between rapid palatal expansion and nickel–titanium palatal expansion appliances. American Journal of Orthodontics and Dentofacial Orthopedics 119: 11–20

Haas A J 1970 Palatal expansion: just the beginning of dentofacial orthopedics. American Journal of Orthodontics 57: 219–255

Haas A J 1973 JCO/Interviews. Journal of Clinical Orthodontics 7: 227–245

Kennedy J W III, Bell W H, Kimbrough O L, James W B 1976 Osteotomy as an adjunct to rapid maxillary expansion. American Journal of Orthodontics 70: 123–137

Kraut R A 1984 Surgically assisted maxillary expansion by opening the midpalatal suture. Journal of Oral and Maxillofacial Surgery 42: 651–655

Krebs A 1964 Mid-palatal expansion studied by the implant method over a seven-year period. Transactions of the European Orthodontic Society, pp. 131–142

Kuo P C, Will L A 1990 Surgical–orthodontic treatment of maxillary constriction. Oral and Maxillofacial Surgery Clinics of North America 2: 751–759

Ladner P T, Muhl Z F 1995 Changes concurrent with orthodontic treatment when maxillary expansion is a primary goal. American Journal of Orthodontics and Dentofacial Orthopedics 108: 184–193

McNamara J A, Brudon W L 1993 Orthodontic and orthopedic treatment in the mixed dentition. Needham Press, Ann Arbor

Northway W M, Meade J B Jr 1997 Surgically assisted rapid maxillary expansion: a comparison of technique, response, and stability. Angle Orthodontist 67: 309–320