Original Article

THE KOREAN JOURNAL *of*
ORTHODONTICS

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Maxillary expansion with the memory screw: a preliminary investigation

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Objective: The purpose of this study was to investigate the effects of a newly developed rapid maxillary expansion screw-the memory screw-over 6 months. **Methods:** Five subjects, aged between 11.7 and 13.75 years, were enrolled in this study. All subjects underwent placement of a maxillary expansion appliance containing superelastic nickel-titanium open-coil springs in its screw bed. The parents of the patients and/or the patients themselves were instructed to activate the expansion screw by 2 quarter-turns 3 times a day (morning, midday, and evening; 6 quarter-turns a day). The mean expansion period was 7.52 ± 1.04 days. Dentoskeletal effects of the procedure, including dentoalveolar inclination, were evaluated. Measurements of all the parameters were repeated after 6 months of retention in order to check for relapse. **Results:** Sella-Nasion-A point (SNA) and Sella-Nasion/Gonion-Menton angles increased, and Sella-Nasion-B point (SNB) angle decreased in all the subjects during the expansion phase. However, they approximated to the initial values at the end of 6 months. On the other hand, the increments in maxillary apical base (Mxr-Mxl) and intermolar widths was quite stable. As expected, some amount of dentoalveolar tipping was observed. **Conclusions:** The newly developed memory expansion screw offers advantages of both rapid and slow expansion procedures. It widens the midpalatal suture and expands the maxilla with relatively lighter forces and within a short time. In addition, the resultant increments in the maxillary apical base and intermolar width remained quite stable even after 6 months of retention.
[**Korean J Orthod 2012;42(2):73-79**]

Key words: Expansion, Appliances, Cephalometrics, Retention and stability

INTRODUCTION

Posterior crossbite is one of the most frequent malocclusions diagnosed clinically.[1] Rapid maxillary expansion (RME) is the most common approach used to correct this anomaly. RME is the rapid physical separation of bones that embryologically develop from both sides and fuse at the midpalatal suture, thereby forming the premaxilla and the bony palate.[2]

The RME procedure, first described by Angell[3] in 1860, is commonly used in the treatment of maxillary transverse deficiency. Almost a century later, Haas[4] reintroduced RME into modern-day orthodontics. Thereafter, remarkable progress has been made in this procedure.

Several previous studies have been undertaken by Isaacson et al.,[5] Isaacson and Ingram,[6] and Zimring and Isaacson[7] to investigate the forces generated during and after RME. The authors observed that the activation of the RME screw by 1 quarter-turn generated 3 - 10 pounds (1.4 - 4.5 kg) of force, which increased cumulatively, reaching 22 pounds (10 kg) on the 15th day of the RME protocol. The intensity of these forces has been reported to reduce sometime later in the retention period and continue decreasing thereafter. The authors stated that pressure sensations in the entire face, infraorbital region, or nose were the result of the accumulated forces. Isaacson and Ingram[6] hypothesized that the expansion might become physiologically stable earlier, thereby reducing the net treatment time, if the expansion procedure involves lower forces.

Orthopedic loads generated during RME force the displacement of the bones adjacent to the maxilla. If these forces are not tolerated by the structures forming the maxillary complex, they may cause severe relapse and tipping of the anchorage teeth.

Darendeliler et al.[8] and Vardimon et al.[9] reported that maxillary expansion with light but continuous forces is feasible and might be less traumatic. This prompted many studies and the development of several appliances aimed at decreasing the heavy forces generated during maxillary expansion or applying only light but continuous forces.

Harberson and Myers[10] reported that midpalatal sutural opening and crossbite correction can be achieved by using the W appliance in the deciduous or mixed dentition. Arndt[11] introduced the nickel-titanium (Ni-Ti) Expander, which is activated by oral temperature and applies 230 - 300 g force. Darendeliler et al.[8] reported that they accomplished maxillary sutural expansion by using magnets that generate 250 - 500 g force.

In a more recent study, Wichelhaus et al.[12] introduced the "Memory Palatal Split Screw" (Forestadent, Pforzheim, Germany; Forestadent USA, 2315 Weldon Parkway, St. Louis, MO 63146; Catalog No: 167M1529). They tested this screw both in clinical practice and in the laboratory by using the Instron universal testing machine and plotted force (N)/deflection (mm) curves for the 6th, 12th, and 24th activations. The investigators found that when the screw was activated 6 times a day, it produced a constant force of 12 - 14 N (1,224 - 1,428 g), which is 2 - 3 times lower than that produced by the conventional screw. In the light of the suggestion by Isaacson and Ingram[6] that a constant force with a low load deflection rate might be the most ideal approach, our preliminary study was aimed at examining the dentoskeletal effects of the memory screw in 5 cases followed up for 6 months.

MATERIALS AND METHODS

Preparation of the appliance and the activation schedule

Informed consents were obtained from the subjects and their parents on enrollment of the patients. Bands of appropriate sizes were seated on the maxillary first premolars and first molar teeth of both sides. An impression with alginate was made, and the bands were transferred to it. Next, a working model was poured in plaster.

The "Memory Palatal Split Screw" described by Wichelhaus et al.[12] was used in the present study. It incorporates superelastic Ni-Ti open-coil springs in the screw bed, which reduce excessive expansion forces. Special precaution was taken to position the screw body parallel to the occlusal plane and as close as possible to the palatal mucosa. Anterior arms of the screw were soldered to the first premolar bands, and the posterior arms were soldered to the first molar bands. In addition, a piece of stainless steel wire (diameter, 1 mm) was soldered between the first premolar and first molar bands. The appliance was cemented using glass ionomer cement. Parents of the patients and/or the patients themselves were instructed to activate the screw by 2 quarter-turns (0.4 mm) 3 times a day (morning, midday, and evening), as proposed by Wichelhaus et al.[12] The expansion was stopped when the palatal cusp of the upper molar teeth occluded with the buccal cusp of the lower molar teeth. The minimum and maximum degrees of expansion were 40 quarter-turns (8 mm) and 50 quarter-turns (10 mm), respectively, and the mean expansion period was 7.52 ± 1.04 days. For stabilization, the appliances were retained in the mouth for 6 months after expansion was completed. The dentoskeletal changes induced by RME were evaluated by lateral (Figure 1) and posteroanterior (Figure 2) cephalograms.

Determination of dentoalveolar tipping

Several methods have been developed for the evaluation of dentoalveolar tipping occurring during RME. Since it has been claimed to be an easy procedure, the method proposed by Oktay and Kiliç[13] was used in the present
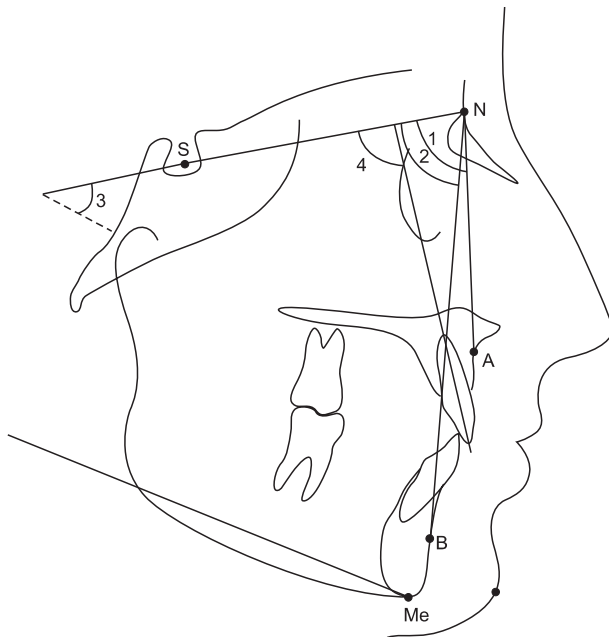
Figure 1. Landmarks and angular measurements on lateral cephalometric radiograph. The sella-nasion-A point (SNA) (1) angle relates to the anteroposterior position of the maxillary apical base to a line passing through the anterior cranial base. The sella-nasion-B point (SNB) (2) angle relates to the anteroposterior position of the mandibular apical base to a line passing through the anterior cranial base. The mandibular plane–anterior cranial base plane (sella–nasion/gonion-menton [SN-GoMe]) (3) angle relates to the cant of the mandibular plane to a line passing through the anterior cranial base. The maxillary incisor to anterior cranial base plane (1-SN) (4) angle relates to the axial inclination of the most labial maxillary incisor to a line passing through the anterior cranial base.

study. As described by the authors, a thin line (1 mm in diameter) was drawn on maxillary stone casts with a paintbrush by using barium sulphate solution. The line was started at the gingival margin of the mesio-buccal cusp of the upper right first molar, passed through the tips of the mesio-buccal and mesio-palatal cusps of the tooth and the palatal vault between the first molars, and ended at the vestibular gingival margin of the upper left first molar. Then, the plaster models were placed in a plastic box with cabinets to allow the passage of X-rays, and a radiographic image was obtained.

Right (α1) and left molar crown tipping (α2) and alveolar process inclination (α3) caused by RME were determined with the aid of landmarks traced on the image (Figure 3). Treatment progress of a patient has been demonstrated in Figures 4-7.
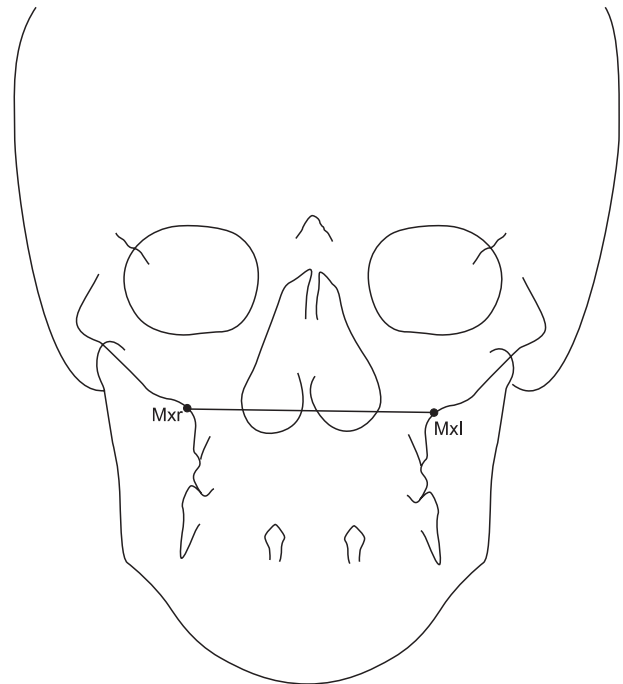

Figure 2. Landmarks and linear measurement on postero-anterior radiograph. Maxillary-maxillary apical base width (Mxr–Mxl) was defined as the horizontal distance between the right and left intersections of the lateral contour of the maxillary alveolar process and the lower contour of the zygomatic process of the maxilla.
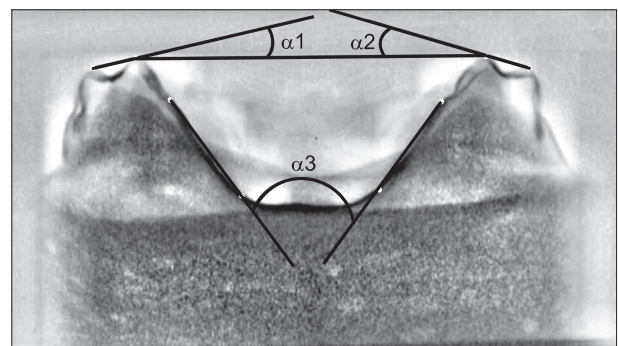
Figure 3. Formation of the angles used for inclination assessment. α1 (right molar tipping angle) and α2 (left molar tipping angle), inner angles between the transversal occlusal line connecting the mesio-palatal cusp tips of the right and left molars and the lines passing through the mesio-buccal and mesio-palatal cusp tips of the molars. α3 (palatal tipping angle), inner angle between the right and left alveolar lines connecting the upper and lower alveolar tipping points on each side.

Fig 4. Pretreatment photographs of a patient.

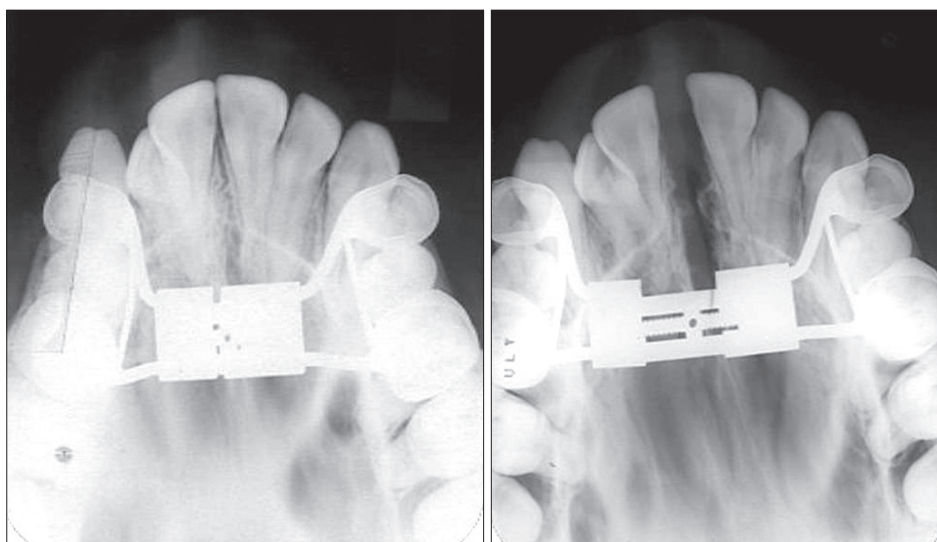**Figure 5.** Photographs after the completion of maxillary expansion.

Figure 6. Occlusal radiograph showing sutural separation.

RESULTS

Dentoskeletal effects

Parameters measured in each individual during the observation period are listed below. The measurements are provided in Table 1.

Sella-nasion-A point (SNA): In all subjects, the SNA angle increased at the expansion phase and some recovery took place at retention. However, at the end of 6 months (T2), the SNA angle was still greater than that at the beginning (T0).

Sella-nasion-B point (SNB): With RME, the SNB angle decreased in every subject; however, it was restored almost totally by the end of the retention period.

Sella-nasion/Gonion-menton (SN-GoMe): This angle increased by approximately 2 degrees in each patient during the expansion phase. A partial recovery took place by retention.

Upper incisor inclination (1-SN): In all the subjects, a slight increase was seen in this angle at first, but it decreased thereafter.

Maxillary apical base width (Mxr-Mxl): The maxillary apical base width increased by more than 4 mm in all subjects but one. The increments remained fairly stable during the retention period.

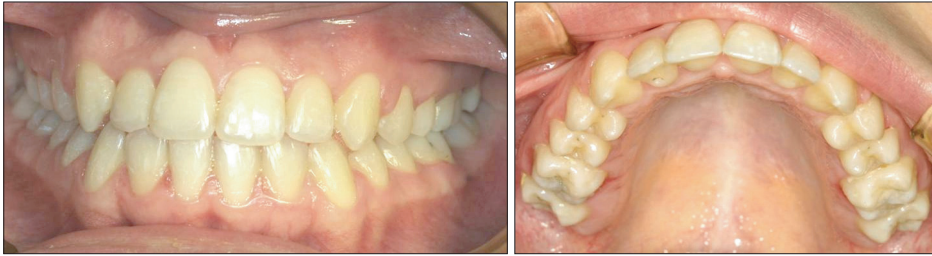**Intermolar width:** The increment in this dimension was

Figure 7. Post-treatment photographs.

Table 1. Dentoskeletal measurements during the observation period

	Patient	1	2	3	4	5
	Sex Age (yr)	Male 12.7	Female 13.75	Female 13.25	Male 11.7	Female 13
Sella-nasion-A point (SNA) (°)	T0	75.7	77.0	77.7	76.9	70.8
	T1	77.9	77.6	79.2	79.1	71.8
	T2	76.0	77.3	78.3	78.5	71.2
Sella-nasion-B point (SNB) (°)	T0	72.3	78.3	76.6	77.0	70.0
	T1	72.0	75.7	76.0	76.6	68.5
	T2	72.2	77.3	76.4	77.1	70.9
Sella-nasion/Gonion-menton (SN-GoMe) (°)	T0	36.1	37.3	36.1	35.2	37.9
	T1	38.1	39.3	38.1	37.1	39.6
	T2	36.9	38.7	37.4	36.4	39.1
Upper incisor inclination (1-SN) (°)	T0	88.5	104.2	103.1	102.6	96.4
	T1	89.3	107.1	104.8	103.2	98.0
	T2	88.0	99.8	102.5	101.8	95.2
Maxillary apical base width (Mxr-Mxl) (mm)	T0	64.6	63.7	57.3	56.6	57.9
	T1	69.3	67.9	61.6	60.4	62.3
	T2	69.3	67.8	61.7	60.2	62.3
Intermolar distance (mm)	T0	41.84	38.87	37.33	38.33	38.53
	T1	50.78	46.65	44.16	46.55	47.46
	T2	51.78	46.99	44.85	47.78	48.41
Right molar crown tipping ($\alpha1$) (°)	T0	3.80	3.20	8.60	4.40	1.10
	T1	12.80	11.20	13.60	17.30	12.40
	T2	13.10	11.40	10.30	21.60	11.10
Left molar crown tipping ($\alpha2$) (°)	T0	11.80	5.60	15.80	5.90	1.40
	T1	19.70	16.40	16.80	20.00	12.60
	T2	20.10	16.80	19.00	21.60	13.20
Alveolar process inclination ($\alpha3$) (°)	T0	61.00	44.50	67.10	49.80	59.10
	T1	72.90	54.10	73.50	62.70	68.40
	T2	73.00	54.50	74.20	63.10	68.50

between 6.83 and 8.94 mm. It continued to increase during the retention period.

Right molar tipping: All subjects showed increases in right molar tipping as a result of RME. In 2 patients, recovery was seen to some extent at retention; however, tipping continued to increase in the remaining subjects.

Left molar tipping: In all the subjects, the degree of left molar tipping increased during both the active and retention periods.

Alveolar process inclination: Alveolar processes tipped

by an average of 10.02 degrees with expansion and remained relatively stable during retention.

DISCUSSION

Several screw-activation schedules have been advocated for RME. In the study by Haas,[4] on the first day, the screw was given a full turn over a 15-minute period, i.e., a quarter-turn every 5 minutes; thereafter, the screw was activated twice daily. Biederman[14] began the schedule with 3 quarter-turns daily, followed by 1 quarter-turn each in the morning and night. Zimring and Isaacson[7] recommended that a regimen of quarter-turns twice daily for the first 4 to 5 days, followed by activation once a day throughout the remaining treatment period. Thus, activation twice daily is the most commonly recommended schedule. However, the screw introduced by Wichelhaus et al.[12] is activated 6 quarter-turns per day, and the present study was aimed at evaluating the dentoskeletal effects of this unusual procedure over a 6-month period.

The maxillary expansion procedure has both dental and skeletal effects. During RME, heavy forces are applied to induce skeletal expansion, and although unwanted, dentoalveolar tipping occurs unavoidably.[15-20]

RME is thought to bring about a forward displacement of the maxilla.[4,18,21] However, during the period of stabilization, the predominant movement of the maxilla is reported to be in the direction of recovery, as noted in our study.[18] Further, according to Wertz,[18] RME almost always causes the mandibular plane angle to open, and this opening is usually accompanied by a diminished SNB angle. This finding is also in agreement with ours. Moreover, maxillary incisors have been reported to drop back and decrease their angulations, as observed in our study.[18]

Although relapse after maxillary expansion is a common concern discussed in the literature,[17,22,23] we did not find any decrease in Mxr–Mrl and intermolar dimensions in the present study during the 6-month retention period. Conversely, intermolar width continued to increase in this period. This was most probably the effect of the Ni-Ti springs present in the screw bed. In fact, during the retention period, these Ni-Ti springs may resist the residual forces, which are believed to be the cause of relapse.

Right molar, left molar, and palatal tipping values (9.24, 9, and 10.02 degrees, respectively) measured at the completion of the expansion phase (T1) in this study were similar to those noted in the study by Kiliç et al.[15] (9.47, 9.16, and 11.30 degrees, respectively), which used the same method for tipping evaluation.

In contrast, molar teeth are expected to tip during expansion and are upright at retention.[17] However, in the present study, the right and left molar tippings (α1 and α2) were noted to generally increase during the retention period. This, again, can be attributed to the Ni-Ti springs in the screw that exert continuous force and prevent molar teeth from becoming upright.

Considering the aforementioned points, the maxillary expansion procedure using the memory screw introduced by Wichelhaus et al.[12] can be considered a combination of rapid and slow expansion protocols. Since the screw is activated 6 times a day and the active phase of the treatment is completed in almost a week, it is a very rapid (maybe an ultra-rapid) expansion procedure. Moreover, the integrated springs have been reported to produce forces 2 - 3 times weaker (1,224 - 1,428 g) than those generated by conventional screws.[9,12] Therefore, the force generated is almost similar to that generated in the slow expansion procedure. (Hicks[17] described a slow maxillary expansion by using 2 pounds-approximately 900 g-of force.)

CONCLUSION

We postulated that the use of the newly developed memory screw, which generates relatively low and constant forces, enables the completion of the active phase of maxillary expansion in almost a week. The dentoskeletal effects of the procedure appear similar to those of conventional screws, except for increased dentoalveolar tipping, which occurred with the memory screw. Neither relapse nor any complications were observed during the observation period of 6 months. However, long-term investigations on larger samples may be more conclusive.

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