A New Nickel Titanium Rapid Maxillary Expansion Screw

ANDREA WICHELHAUS, DDS, PHD
MARC GESERICK, DDS
JUDITH BALL, BCD, MSC, MOrth

Rapid maxillary expansion (RME) is often used in patients who have severe transverse maxillary deficiencies combined with crossbites,[1] in patients with small apical bases, and to resolve minor crowding in some mixed dentition cases.[2] RME can also facilitate spontaneous correction of Class II and Class III malocclusions.[2] In patients with vertical growth patterns, it can improve nasal respiration by increasing the volume of the nasal airway.[3,4]

Because of developmental factors, posterior crossbite should be corrected early in the deciduous dentition.[5,6] The heavy forces applied against the anchor teeth during conventional RME, however, can lead to denticle formation in the pulp, bony exostoses, and root resorption.[7-11] Isaacson and colleagues have shown that the midpalatal suture can be opened with lighter forces, which would reduce these risks.[8]

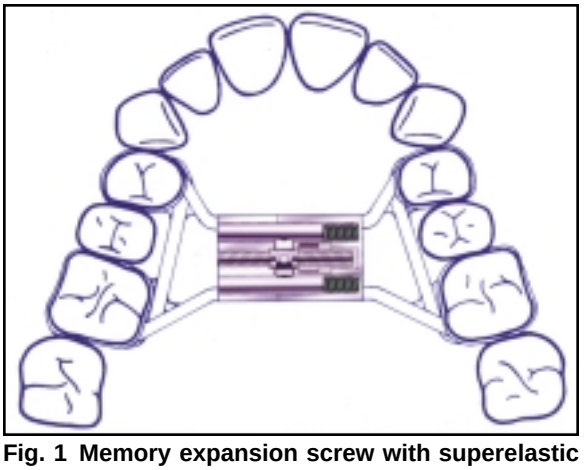

Fig. 1 Memory expansion screw with superelastic nickel titanium spring.

The shape memory and superelasticity of nickel titanium alloys[12-15] have made it possible to apply such physiologic forces and thus to make maxillary expansion shorter in duration and more effective, as described by Wichelhaus and Sander.[16-19] A new maxillary Memory Palatal Split Screw* with a superelastic nickel titanium spring (Fig. 1) is described and evaluated in this article.

Laboratory Test

Biomechanical testing of the Memory expansion screw was carried out at 37°C using an Instron** universal testing machine. Results were analyzed with Origin 6.1*** software and plotted on force/deflection curves according to the number of 90° activations of the screw: six,

*Forestadent, Pforzheim, Germany; Forestadent USA, 10240 Bach Blvd., St. Louis, MO 63132.

**Instron Corporation, Canton, MA.

***OriginLab Corporation, Northampton, MA.

Dr. Wichelhaus is Chairperson, Dr. Geserick is an Assistant Professor, and Dr. Ball is an Associate Professor, Department of Orthodontics, University of Basel, Hebelstrasse 3, CH-4056, Basel, Switzerland. Dr. Geserick is also in the private practice of orthodontics in Ulm, Germany. E-mail Dr. Wichelhaus at andrea.wichelhaus@unibas.ch.

Dr. Wichelhaus

Dr. Geserick

Dr. Ball

12, or 24 (Fig. 2).

For the expansion screw that was turned six times, the graph was linear—that is, the force was directly proportional to the activation—for the initial .05mm. A plateau was reached at 17N (1,734g) of force, and the force remained constant with further compression of the screw. The deactivation curve, representing the active force in the mouth, reached a plateau at 14N (1,428g) of force. For the expansion screws turned 12 and 24 times, force levels were also independent of the degree of activation, but the plateaus were at lower levels.

Clinical Test

Ten patients with an average age of 9.4 years were treated with this appliance. Impressions and anterior occlusal radiographs were taken and transverse arch widths measured at the beginning and end of active expansion.

Each screw was activated six times a day, for a maximum of two weeks. The constant force level of 12-14N (1,224-1,428g) produced effective and rapid expansion, and the midpalatal suture opened within one week in every patient, as confirmed by radiographs. Patients reported no pain during active treatment, regardless of the amount of activation. After sufficient expansion had been achieved, each screw was sealed with acrylic to prevent further activation during a six-month retention period.

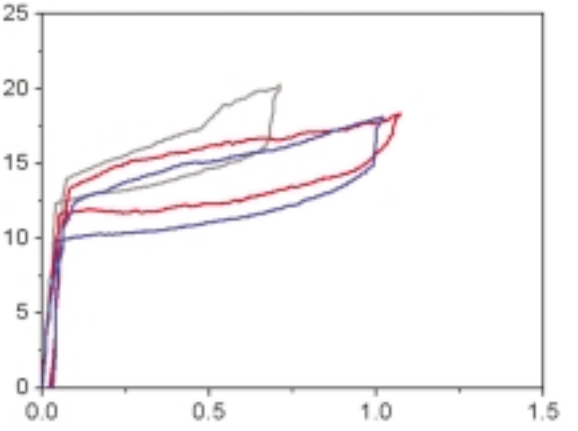

Fig. 2 Force (N)/deflection (mm) curves for memory expansion screws activated 90° six times (gray), 12 times (red), and 24 times (blue).

The 10 patients showed a mean anterior arch-width gain of 6.88mm ± 2.47 and a mean posterior arch-width gain of 7.88mm ± 2.07 (Fig. 3). T-tests confirmed that the results were statistically significant.

Case Report

A 12-year-old female patient presented with a crossbite due to a symmetrical constriction of the maxilla and a narrow apical base. Rapid maxillary expansion was indicated by the coexistence of a crossbite with a skeletal open bite and functional problems.

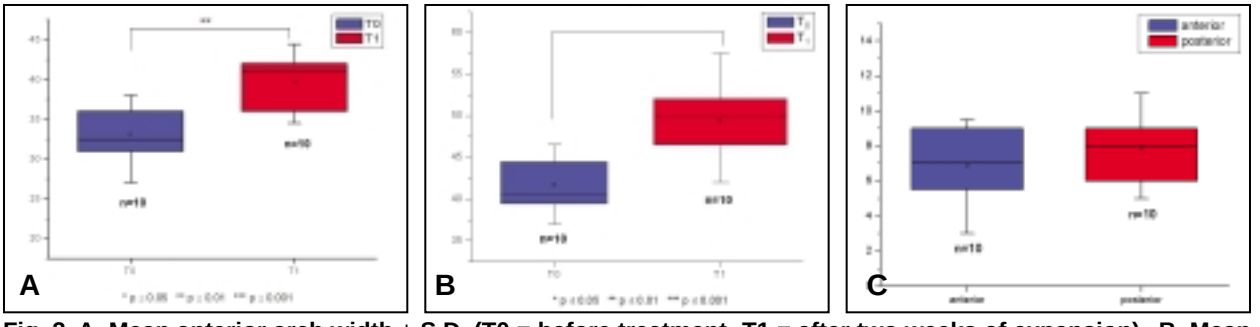

Fig. 3 A. Mean anterior arch width ± S.D. (T0 = before treatment; T1 = after two weeks of expansion). B. Mean posterior arch width ± S.D. (T0 = before treatment; T1 = after two weeks of expansion). C. Mean changes in anterior and posterior arch width after two weeks of expansion.

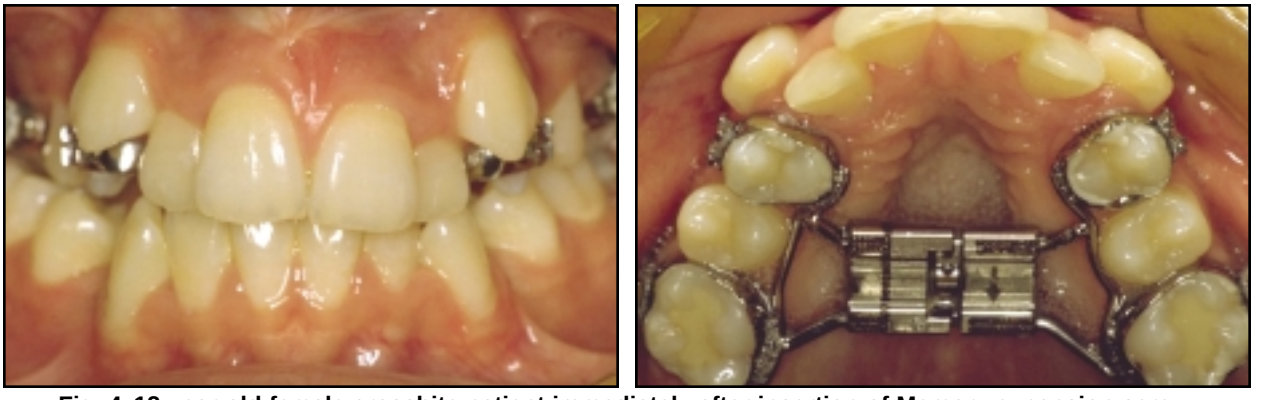

Fig. 4 12-year-old female crossbite patient immediately after insertion of Memory expansion screw.

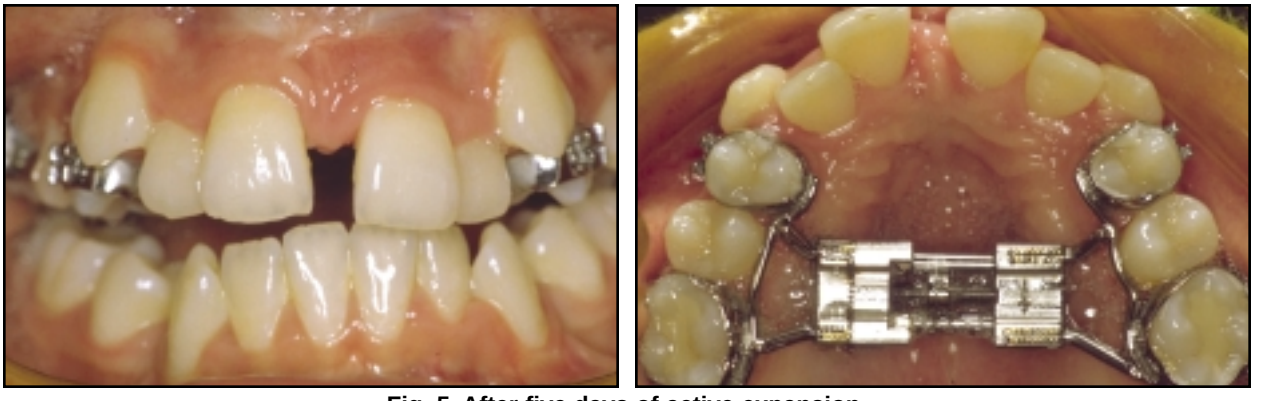

Fig. 5 After five days of active expansion.

The Memory expansion screw was laser-welded directly to the first molar bands (Fig. 4). The parent was shown how to activate the appliance six quarter-turns per day: two in the morning, two after lunch, and two in the evening.

This rapid and constant expansion was well tolerated by the patient. After five days, the crossbite had been eliminated (Fig. 5). An anterior occlusal radiograph verified the opening of the midpalatal suture (Fig. 6). The screw was then sealed with composite to retain and stabilize the expansion for six months. Orthodontic treatment was subsequently completed with premolar extractions and fixed appliances.

Discussion

Marzban and Nanda have shown that the

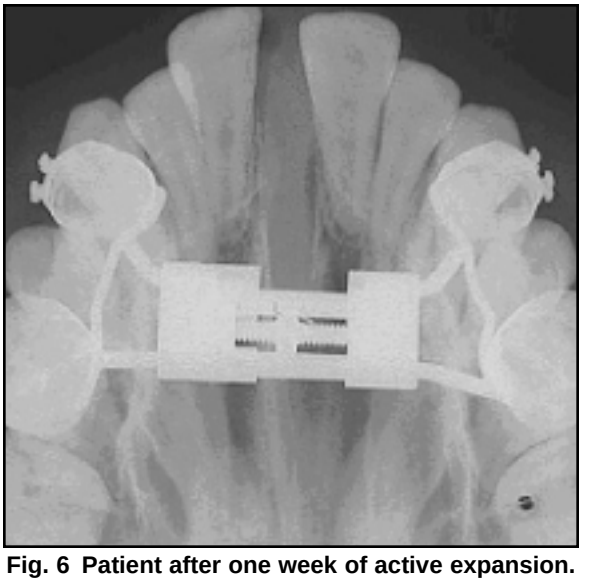

Fig. 6 Patient after one week of active expansion.

facial sutures and periodontal tissues behave similarly in response to applied force systems.[20] The teeth and craniofacial bones are essentially constrained bodies, one limited by the periodontium and the other by the craniofacial sutures.

RME has a skeletal component, involving separation of the maxilla at the midpalatal suture, and a dental component, resulting from buccal tipping of the maxillary posterior teeth. The proportion of skeletal and dental movement depends on the rate of expansion and the age of the patient. If the applied transverse forces are sufficient to overcome the bioelastic stress of the sutural elements, orthopedic separation of the maxillary segments will occur.[21,22] The objective of RME is to reduce undesirable dental movement while producing enough force to inhibit movement of the anchor teeth, thus maximizing the orthopedic response.[23,24]

Conventional RME appliances generate about 2,000-5,000g of force per quarter-turn, with accumulated loads as high as 9,000g, which can lead to uncontrolled tipping and subsequent root resorption.[8] The superelasticity of nickel titanium makes it possible to apply a lighter, more physiologic force.[3,4,16-19] Although 450-900g of force is not enough to cause separation of a mature suture,[9] testing of the Memory expansion screw indicated that the first six activations produce as much as 1,700g of force. The constant force level of 1,225-1,425g is sufficient to continue opening the suture, but two or three times lighter than with conventional screws. Therefore, the screw can be activated as many as six times per day with minimal patient discomfort. Based on our initial clinical experience, we recommend three quarter-turns in the morning and three in the evening until the desired expansion is achieved—usually within one or two weeks.

REFERENCES

1. Kurol, J. and Berglund, L.: Longitudinal study and cost-benefit analysis of the effect of early treatment of posterior cross-bites in the primary dentition, Eur. J. Orthod. 14:173-179, 1992.
2. McNamara, J.A. Jr.: Early intervention in the transverse dimension: Is it worth the effort? Am. J. Orthod. 121:572-574, 2002.
3. Warren, D.W.; Hershey, H.G.; Turvey, T.A.; Hinton, V.A.; and Hairfield, W.M.: The nasal airway following maxillary expansion, Am. J. Orthod. 91:111-116, 1987.
4. White, B.C.; Woodside, D.G.; and Cole, P.: The effect of rapid maxillary expansion on nasal airway resistance, J. Otolaryngol. 18:137-149, 1989.
5. Hensel, E.: The development of dysgnathia from the primary dentition to the mixed dentition, Fortschr. Kieferorthop. 52:353-358, 1991.
6. Ingervall, B. and Thilander, B.: Activity of temporal and masseter muscles in children with a lateral forced bite, Angle Orthod. 45:249-285, 1975.
7. Greenbaum, K.R. and Zachrisson, B.U.: The effect of palatal expansion therapy on the periodontal supporting tissues, Am. J. Orthod. 81:12-21, 1982.
8. Isaacson, R.J.; Wood, J.L.; and Ingram, A.H.: Forces produced by rapid maxillary expansion, Angle Orthod. 34:256-270, 1964.
9. Storey, E.: Tissue response to the movement of bones, Am. J. Orthod. 64:229-247, 1973.
10. Timms, D.J. and Vero, D.: The relationship of rapid maxillary expansion to surgery with special reference to midpalatal synostosis, Br. J. Oral Surg. 19:180-196, 1981.
11. Timms, D.J. and Moss, J.P.: An histological investigation into the effects of rapid maxillary expansion on the teeth and their supporting tissues, Trans. Eur. Orthod. Soc. 263-271, 1971.
12. Andreasen, G.; Wass, K.; and Chan, K.C.: A review of superelastic and thermodynamic nitinol wire, Quintess. Int. 16:623-626, 1985.
13. Arndt, W.V.: Nickel titanium palatal expander, J. Clin. Orthod. 27:129-137, 1993.
14. Es-Souni, M.; Es-Souni, M.; and Fischer-Brandies, H.: On the properties of two binary NiTi shape memory alloys: Effects of surface finish on the corrosion behaviour and in vitro biocompatibility, Biomater. 23:2887-2894, 2002.
15. Miura, F.; Mogi, M.; and Ohura, Y.: The super-elastic property of the Japanese NiTi alloy wire for use in orthodontics, Am. J. Orthod. 90:1-10, 1986.
16. Sander, F.G.: Festigkeit und Elastizität kieferorthpädischer Drähte unter Berücksichtigung der superelastischen Materialien, Inf. Orthod. Kieferorthop. 22:489-499, 1990.
17. Wichelhaus, A. and Sander, F.G.: Biomechanical testing of the new torque segmented arch, Fortschr. Kieferorthop. 56:224-235, 1995.
18. Wichelhaus, A. and Sander, F.G.: Development and testing of a new NiTi-SE-steel uprighting spring, Fortschr. Kieferorthop. 56:283-295, 1995.
19. Wichelhaus, A.; Sander, C.; and Sander, F.G.: Development and biomechanical investigation of a new compound palatal arch, J. Orofac. Orthop. 65:104-122, 2004.
20. Marzban, R. and Nanda, R.: Slow maxillary expansion with nickel titanium, J. Clin. Orthod. 33:431-441, 1999.
21. Braun, S.; Bottrel, J.A.; Lee, K.G.; Lunazzi, J.J.; and Legan, H.L.: The biomechanics of rapid maxillary sutural expansion, Am. J. Orthod. 118:257-261, 2000.
22. Cameron, C.G.; Franchi, L.; Baccetti, T.; and McNamara, J.A. Jr.: Long-term effects of rapid maxillary expansion: A postero-anterior cephalometric evaluation, Am. J. Orthod. 121:129-135, 2002.
23. Ciambotti, C.; Ngan, P.; Durkee, M.; Kohli, K.; and Kim, H.: A comparison of dental and dentoalveolar changes between rapid palatal expansion and nickel-titanium palatal expansion appliances, Am. J. Orthod. 119:11-20, 2001.
24. Cozzani, M.; Mirenghi, S.; and Guiducci, A.: Rapid maxillary expansion in the mixed dentition: Permanent maxillary incisor, Inf. Orthod. Kieferorthop. 35:107-112, 2003.