Locking the Screw after Rapid Palatal Expansion: A Superfluous Procedure?

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The rapid palatal expander (RPE) is widely used to correct maxillary constriction. Clinically, there are only a few differences among the various expansion protocols, including the number and frequency of turns (activation rate) of the midline jackscrew for rapid or slow expansion,[1,2] the attachment method (banded or bonded acrylic),[3] and the decision whether to use deciduous or permanent teeth for anchorage.[4]

The screw of an RPE is commonly blocked with composite or a stainless steel ligature after the desired expansion has been achieved, the objective being to prevent relapse due either to the forces generated by stretched tissues of the enlarged maxillary bone trying to return to their previous state[5] or to back-turning from manipulation by the tongue.[6] Little research has been published, however, that might confirm such relapse.

We used a prospective clinical trial and a theoretical approach to investigate whether it is necessary to lock the screw after active expansion.

Materials and Methods

The prospective clinical trial was performed in Dr. Huanca Ghislanzoni's private practice. Because a statistical power greater than .9 was desired, a sample size of at least 45 subjects was needed. Forty-eight consecutive patients (21 males and 27 females) presenting with maxillary deficiency, as indicated by a unilateral or bilateral crossbite, were chosen for treatment with rapid palatal expansion. The mean age at the start of treatment was 7.8 ± 1.2 years.

A Hyrax expansion screw* coated with a

*Part A0620, Leone S.p.A., Sesto Fiorentino, Florence, Italy; www.leone.it.

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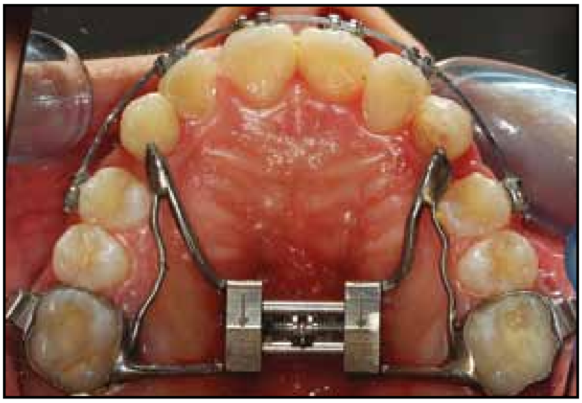

Fig. 1 Rapid maxillary expander cemented to first molars.

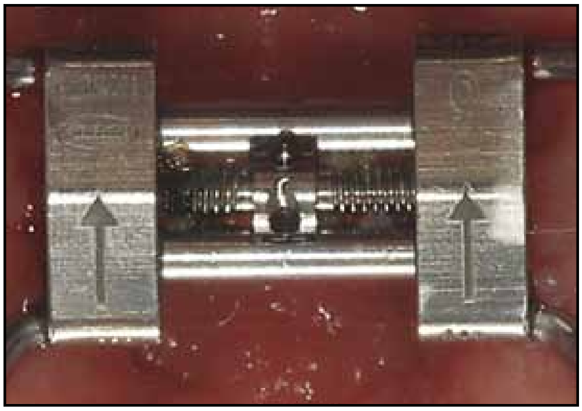

Fig. 2 Notch carved in lingual surface of spindle as reference mark to indicate any relapse of expansion screw.

friction agent was cemented to the first molars of each patient (Fig. 1). A full turn of the screw provided .8mm of expansion. The treatment protocol was the same for each patient: two quarter-turns per day (.4mm of expansion), with weekly visits to note progress. The active expansion phase lasted a mean 15 ± 3 days. In each case, when the amount of expansion was judged satisfactory, with a slight overcorrection, a notch was carved with a diamond bur into the lingual surface of the screw spindle (Fig. 2). The notch served as an unambiguous reference point for any backward movement of the screw components, since such movement would cause a displacement of the notch. The screws were not blocked with composite or ligatures.

After an average 5.5 months of retention with passive expanders, the appliances were removed. At the debanding appointment, each screw's notch position was checked, and the number of reverse turns needed to deactivate the screw was counted to verify that none of the screws had reversed by exactly one or more full turns, which might have created an illusion of stability.

Results

All 48 patients completed the treatment. An average 30 quarter-turns were made, resulting in an average screw opening of 6.1 ± 1.2mm. None of the notches was found to be displaced, and the number of "deactivation" turns matched the number of activations in each subject. Since there had been no relapse in any of the patients, no further statistical analysis of the results was required.

Discussion

Locking the jackscrew in place after achieving the desired rapid palatal expansion is a universal clinical management tip that actually appears to have little substantiation. The resistance force of the maxillary tissues against the expander was studied by Isaacson and colleagues in five patients, using a modified RPE with a dynamometer connecting the expansion screw and the bands on one side of the mouth to an acrylic plate placed against the palatal alveolar process of the opposite side.[7-9] The expansion screw was activated .8mm per complete turn, as in many current RPE designs. In four of the patients, the forces measured by the dynamometer dropped to zero five to seven weeks after the end of active expansion. In the fifth patient, for whom the maximum possible daily activations were performed in the clinic, a drop to zero was noted after only five days. This sudden decrease was attributed to back-turning of the screw, perhaps caused by masticatory function or manipulation by the patient. In a more recent study, Halazonetis and colleagues measured the contribution of the stretched cheeks in resisting maxillary

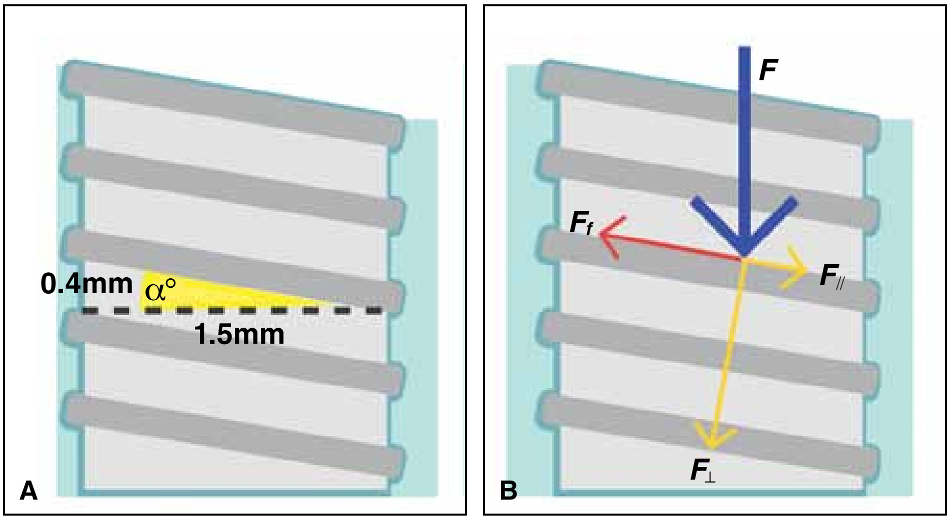

Fig. 3 Screw characteristics and resulting forces. A. Screw pitch and thread slope. B. Direction of forces.

expansion; results showed a negligible .6g/cm^2 per millimeter of expansion.[10]

Other factors that could be considered potential causes of back-turning are vibrations and lubrication. Vibrations at a particular resonance frequency can cause a screw to unseat. In the mouth, the voice can produce vibrations ranging from 60 to 2,000Hz, with averages of 100Hz for an adult man, 200Hz for an adult woman, and 400Hz for a child.[11,12] Although no data have been published on the resonance frequency of an RPE screw system, it seems unlikely that vocal vibrations could affect the stability of expansion treatment.

A lubricant reduces the strength and number of bridges formed between the asperities of sliding surfaces.[13] In studies using artificial saliva, friction has been variously found to decrease,[14] stay the same,[15] or increase[16] during orthodontic treatment. Tselepis and colleagues reported a drop in frictional force between stainless steel brackets and archwires of as much as 60% under lubrication with artificial saliva.[17] Even this much reduction in static friction would not be enough to allow any screw to turn back, however, as demonstrated by the following theoretical discussion.

Geometrical analysis shows that an RPE screw cannot be unintentionally turned back as long as the slope of each thread does not exceed a critical value of 36.5°. In fact, the slope of the threads is the key factor. Our calculations were based on the specific manufacturing details of the screw used for the present study, but they may be applied to virtually any screw of similar thread pitch and slope.

The Leone A0620 screw has a mean diameter of 1.5mm; a full turn provides .8mm of activation (expansion). Assuming the screw of the RPE is centered symmetrically between two metal blocks moving away from each other, this means that for every full turn, each block moves .4mm away from the center. That value also represents the pitch of the screw—the distance between the centers of two contiguous threads as measured along the long axis (Fig. 3A). The slope of the thread (the angle between the thread and a plane perpendicular to the long axis), can be calculated using the equation:

$$\alpha = \arctan\left(\frac{pitch}{\pi \times diameter}\right) \quad \text{(Eq. 1)}$$

By applying this equation to the A0620 screw, the thread-slope angle, α, is shown to be 4.9°.

The forces from the stretched maxillary tissues, acting parallel to the long axis of the screw, may be broken down into two parts (Fig. 3B): $F_{//}$ (parallel to the threads) and $F_{\perp}$ (perpendicular to the threads). $F_{//}$ alone could theoretically cause the screw to turn back because it acts as a tangential force, creating a moment around the long axis of the screw. $F_{\perp}$ is assumed to be the force responsible for frictional resistance to turning.

The force of static friction is calculated by multiplying the normal force by the coefficient of friction, which for stainless steel is about .74.[18]

This force, F_f, acts in the same direction as, but in opposition to, $F_{//}$. If $F_{//}$ is greater than F_f, the screw can turn around its axis; otherwise, it will not move. An angle of 36.5° (the arctangent of .74) is the critical angle at which $F_{//}$ is equal to F_f. Under normal conditions, it is impossible for a shallower-threaded screw to turn back, because the frictional forces will always be greater than the parallel forces (Fig. 3B).

Projecting the compression force F onto a coordinate system parallel to the slope of the threads, F can now be expressed in terms of components parallel to ($F_{//}$) and perpendicular to ($F_{\perp}$) the threads:

$$F_{//} = F\sin\alpha \quad \text{(a)}$$
$$F_{\perp} = F\cos\alpha \quad \text{(b)}$$
$$F_f = \mu F\cos\alpha \quad \text{(c)} \quad \text{(Eq. 2)}$$

where α is the slope of the threads and μ is the coefficient of friction. The applied load cannot cause the screw to back out unless the component of the force parallel to the threads is greater than the force of friction:

$$F_{//} > F_f \quad \text{(Eq. 3)}$$

From the identities in Equation 2, it follows that for the screw to back out, the condition

$$\tan\alpha > \mu \quad \text{(Eq. 4)}$$

must be met. For μ to equal .74, α must be greater than 36.5°, which is unlikely with any normal thread design. Alternatively, for α to equal 4.9°, the coefficient of friction would need to be less than .09 in the static case described here.

Conclusion

Our prospective clinical trial and theoretical considerations show that locking the expansion screw of an RPE at the end of active expansion is an unnecessary precaution in most situations. The shallow slope of virtually any expansion-screw threads will prevent relapse of the expansion mechanism. Although our clinical study used a screw coated with a friction agent, it appears from our calculations that such coatings, as well as the ratcheting-type mechanisms incorporated in many screws, may be superfluous.

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