A Jointed Fan-Type Expander: A Newly Designed Expansion Appliance for the Upper Dental Arch of Patients With Cleft Lip and/or Palate

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Most patients with repaired cleft lip and/or palate have malocclusion and show various forms of occlusal discrepancy between the upper and lower dentition. In unilateral clefts, the teeth in the collapsed small segment are usually in lingual crossbite, although in most cases they are in normal buccolingual occlusal relation in the molar region. Expansion appliances should fulfill the following functions: the application of expansion force to the alveolar bone of the maxillary complex without buccal tipping of the teeth (to obtain the differential segmental movement); force to the lateral segments of the maxilla without their distortion; and expansion of the smaller segment without creating posterior crossbite. Unfortunately, many appliances do not satisfy these functions. A new fan-type expansion appliance has been designed by the authors to solve these problems. This appliance consists of three parts, as follow: an expansion screw; four bands (anchorage); and a joint connecting both buccal segments. The expansion screw is set in a direction tangent to the curve drawn by the intended fan-type movement of the collapsed small segment. The joint converts the expansion force from parallel to an arched direction.

KEY WORDS: jointed fan-type expander, cleft lip and palate, fan-type expansion, expansion screw, appliance.

The growth of the maxillary dental arch of patients with cleft lip and/or palate is inhibited by growth impairments that are caused by tissue defects and possibly by the effects of surgery. Most patients with repaired cleft lip and/or palate have malocclusions and show various forms of occlusal discrepancy between the upper and lower arches. Many patients with bilateral clefts have normal buccolingual relations in the molar region, but may have crossbite in the canine and bicuspid regions. Patients with unilateral clefts also have crossbite in the lesser segment, although a normal occlusal relation may occur in the molar region.

The fixed-type expansion appliance with an ordinary screw exerts parallel forces to the alveolar bones and the maxillary complex. Thus, the force may expand not only the collapsed segment, but also the normal segment.

Arnold's expander, Poter's lingual arch appliance, Coffin's split (Adams, 1970), the quad helix appliance (Ricketts, 1973), the fan-type screw expansion plate (Schwartz and Gratzinger, 1966; Graber, 1972), the fan-type expansion appliance (Haas, 1965), and the lingual arch (Sakuda et al, 1982) may provide unilateral expansion of the collapsed alveolar region in cleft lip and/or palate cases. However, these appliances do not fully provide the following functions: (1) a fan-type expansion force to the alveolar bone of the maxillary complex without buccal tipping of the teeth (to obtain the differential segmental movement); (2) force to the buccal segments of the maxilla without their distortion between the part where the force was applied and the rest of the segment; and (3) force for obtaining fan-type expansion of the lesser segment without creating posterior crossbite. A new fan-type expansion appliance has been designed by the authors to solve these problems.

APPLIANCE DESIGN AND FABRICATION

This appliance consists of three parts, as follows: (1) an expansion screw; (2) four bands; and (3) a joint connecting both buccal segments (Fig. 1). The expansion screw and the four bands are the same as the components of the conventional skeleton-type expansion appliance. The newly added part of this appliance is the joint that converts the expansion force from a parallel direction to an arched direction.

An expansion screw (Dentaurum) is used for this appliance and has two retention holes (Fig. 1A). The joint is made in one hole, and the connecting orthodontic wire in the larger segment is soldered to the other hole. The solderball is made at the end of the orthodontic wire (1.0 mm in diameter), which connects the lesser segment. The wire (a shaft of the joint) passes through the hole (Fig. 1B) and is bent toward the occlusal plane (Fig. 1C). The screw is set in a direction tangent to the curve drawn by the intended fan-type movement of the lesser segment (Fig. 1D). The wires
that extend from the screw are bent palatally as they come in contact with four anchor bands, which are fitted to the maxillary teeth of both buccal segments. Finally, the wires are soldered to four bands (Fig. 1E). In cases in which the collapse of the lesser segment is severe, the wire from the screw may be soldered to the wire between two bands on the larger segment.

Treatment Results

The occlusal views of the maxillary dental arch before and after expansion in five cases are shown in Figure 2.

**DISCUSSION**

Some difficulties are encountered in the orthodontic treatment of patients with cleft lip and/or palate, mainly because of the insufficient forward and downward growth of the maxillary complex, the abnormal upper dental arch form, and possible ectopic eruption of the upper teeth. Posterior crossbite of the cleft side is often seen in the deciduous dentition. However, the first maxillary molars often erupt with normal relation to the maxilla and occlude with the lower first molars in normal buccolingual relation. Permanent incisors, canines, and premolars may erupt palatally because of surgical scarring. Thus, in the permanent dentition, patients usually have crossbite in the collapsed buccal segment on the cleft side.

Problems encountered with conventional fan-type expansion screw appliances include the following:

1. The force exerted by the fan-type expansion screw distorts the alveolar and basal bone of the maxillary complex or moves the most posterior parts of the maxillary tuberosity inward because the intermolar distance is constant (Figs. 3A, 3B).

2. The force exerted by the fan-type expansion screw is bilateral and difficult to control unequally (Fig. 4), especially in expanding the lesser segment.

3. Reciprocal forces spread the uprighted collapsed segment with an undesirable upward cant.

Other expansion appliances can produce expansion of the dental arches, but they present other problems. For example, Arnold’s expander, which most resembles our appliance, provides parallel expansion by using a round tube and an open coil spring. However, its continuous expanding force may cause the teeth to tip buccally. Harvold’s appliance, Poter’s appliance, and the quad helix appliance use continuous force, which may cause the teeth to overincline buccally. The unilateral expansion appliance (Sakuda et al., 1982) fixes both upper molars and may result in distortion of the buccal segments at the fixed teeth (see Fig. 3B), inward movement of the portions of the maxillary hidden in the oral mucous membrane posterior to the fixed teeth (see
FIGURE 4 The mechanisms by which a conventional fan-type expander (left) and the newly designed fan-type expander (right) work. A, The expansion force applied to the greater segment is larger than that applied to the lesser segment. B, the force to the lesser segment is an expansion force whereas the greater segment is used as anchorage. F and F' are the force and reciprocal force, respectively, applied by the expansion screw. E represents the expanding component of the force and A the anchorage component. L is the greater segment and S the lesser segment.

Fig. 3C), or extrusion of the canines and premolars out of the alveolar bone. Therefore, the distorted maxillary complex may relapse.

The fan-type expansion screw appliance described here uses the sphenoid bone as a hinge for the two separated maxillary components. The expansion obtained by this appliance allows a normal relationship of the posterior dentition without distorting the maxillary complex, resulting in a posterior crossbite.

The force exerted by the screw is reciprocal. If the screw is set perpendicularly to the midline, as in an ordinary fan-type expansion appliance, the expanding component of the force on the larger segment is greater than that on the collapsed lesser segment (see Fig. 4). This results in greater expansion of the larger segment. If the screw is set more perpendicularly to the lesser segment (the segment desired to be moved) than to the larger segment (the segment desired to remain stable), the expanding component of the force distributed to the lesser segment is greater than that to the larger segment (see Fig. 4). Unless the expansion appliance has a joint, the force will result in parallel expansion and not in a fan-type expansion. The joint in the screw diverts the direction of expansion from parallel to arched. Just as a tangent to a curve has only one point, the lesser segment that traces an arched movement cannot follow the linear movement of the expansion screw without a transmitter between the expansion screw and the small segment. Thus, it is necessary that the transmitter has two joints at its ends. Theoretically, this appliance may need two joints. But in clinical practice, one joint is sufficient. If it has two joints, the translation of the expansion force vertically to the occlusal plane is uncertain. The lesser segment is successfully expanded (see Fig. 2) according to both the arrangement of the direction of the screw and the greater mechanical resistance of the larger segment supported by the effect of the joint.

REFERENCES


Commentary

The management of crossbite of the lesser segment, which is frequently seen in unilateral cleft palate cases, presents a mechanical challenge to the orthodontist. A banded or bonded appliance of the Haas or Hyrax type exerts equal and opposite forces to both segments. More objectionable is the equal expansion of the molar and cuspid regions of the lesser segment. Fan-type appliances also have limitations. They can decrease the molar width as the cuspid width is expanded, as reported by Suzuki and Takahama.

Suzuki and Takahama have described a very clever appliance that effectively deals with the problems, while generating minimal adverse side effects. A greater lateral force is delivered to the lesser segment, so it is less likely that the normal side will be expanded. As the force diagram in Figure 4 shows, there is a larger distal force to the nonleft side. It is unlikely that this force will express itself in adverse tooth movement because distal movement is most resistant, particularly when the duration of the force is very short, as is the case with expansion devices.

The authors do not discuss the effective center of resistance of the lesser segment. They mention that the sphenoid bone acts as the hinge, but that undoubtedly refers to the vertical center of resistance. In Figure 2, one of the cases (12 years, 3 months) shows a slight contraction of the proximal portion of the alveolus, which suggests that the center of resistance of the segment is near the molar. With a larger number of cases, the authors could accurately infer the actual center.

Drs. Suzuki and Takahama have described and demonstrated an excellent device for affecting the precise movement necessary in many cases of unilateral cleft lip and cleft palate. It would be helpful if dental supply companies offered kits consisting of the expansion screw and the wire with the ball end.

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