Orthopedic and orthodontic applications of the quad-helix appliance

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There has been an evolution of various types of removable appliances to expand collapsed dental arches.[1] Most of these have been modifications of the time-honored Coffin loop incorporated in a vulcanite plate which was used to expand the upper arch (Fig. 1, *A*). Although this appliance was adjusted periodically, the force it produced was continuous because of the nature and configuration of the palatal compound loop.

One of the most common forms of an expansion removable appliance is that developed by Martin Schwarz and used extensively throughout Europe.[2] It utilizes tissue-borne anchorage, and appurtenances of wire for tooth movement. The expansion force produced by the jackscrew mechanism of this appliance is intermittent as compared to the continuous nature of the Coffin loop described previously.

More recently, Haas[3] and Wertz[4] have recommended rapid expansion of the midpalatal suture for narrow maxillary arches. This is accomplished with a fixed appliance, usually cemented to the maxillary first premolars and first permanent molars, augmented by a palatal jackscrew and acrylic extensions. Because of the greater magnitude of force produced by these fixed appliances, the net effect is a lateral orthopedic movement of the two halves of the maxilla. Chaconas and Caputo[5] found that various fixed expansion appliances produced a different range of load-activation characteristics. This was reflected by the differences in the stresses transmitted through the bones of the craniofacial complex and the effect to the various sutures.

A fixed "W" expansion palatal type of appliance was originally used by Ricketts[6] to treat cleft palate conditions which were accompanied by a collapsed dental arch (Fig. 1, *B*). This appliance acts continuously over a period of time until the initial activation has dissipated.

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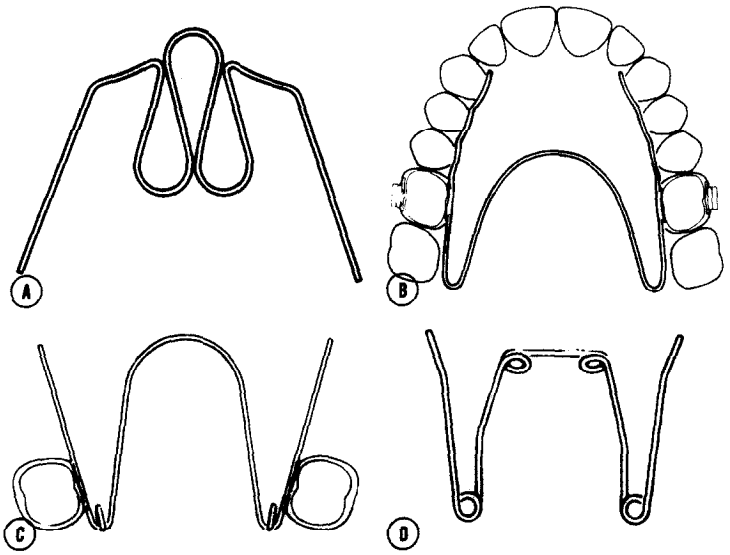

Fig. 1. The evolution of the quad-helix appliance. **A,** Palatal expansion loop, developed by Coffin in 1869, was incorporated in a removable vulcanite plate. **B,** Fixed "W" expansion appliance used to expand maxillary arch of cleft palate patients. More activation is produced in the anterior portion of the arch because of the configuration of the palatal wire. **C,** The modified "W" appliance with the addition of two posterior loops for a greater range of force. **D,** The quad-helix palatal wire with four loops producing more flexibility.

Quad-helix appliance

In order to increase the range of force and produce more flexibility, helical loops were initially incorporated at the posterior segment of the palatal arch (Fig. 1, *C*). The final modification was made by introducing two more loops in the anterior part of the arch, making a total of four and thus creating the "quad-helix" appliance (Fig. 1, *D*). Basically, the appliance is constructed of 0.038 inch (0.975 mm.) wire and soldered to bands which are cemented to either the maxillary first permanent molars or the deciduous second molars, depending on the age of the patient. The initial expansion activation is placed in the appliance prior to cementation, and the net effect is expansion of the buccal segments and a rotation of the banded tooth (Fig. 2, *A*).

Chaconas and Caputo[5] reported that an initial 8 mm. of expansion prior to cementation created approximately 14 ounces of force (Fig. 2, *B*). This force magnitude is sufficient to produce tooth movement, but generally is not enough to create an orthopedic effect on adults when the midpalatal suture is closed. However, in children in the deciduous or early mixed-dentition stages of development, the resistance at the patent suture is often less than in the dentoalveolar area. Therefore, this appliance is capable of orthopedically widening the maxilla in children and thereby creating a normal maxillomandibular relationship.

Orthopedic applications

Fig. 3, *A* illustrates the occlusion of a 5-year-old child in the deciduous dentition. There is an apparent unilateral cross-bite on the patient's left side, as well

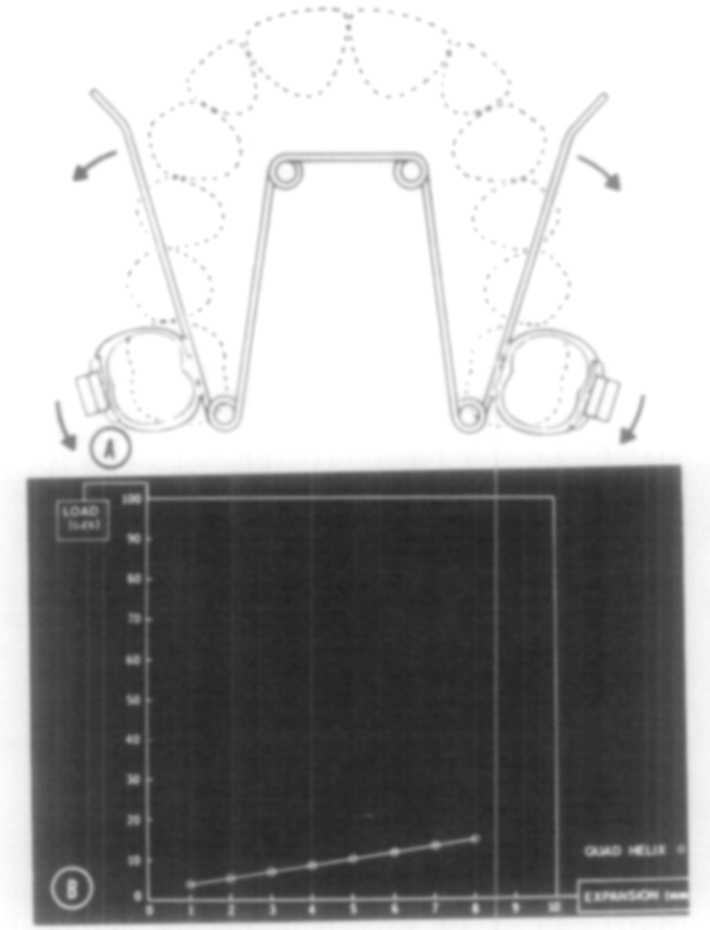

Fig. 2. Force-activation characteristics of the quad-helix appliance. **A,** The force produced by the quad-helix appliance produces not only an expansion of the maxillary buccal segments but also a mesiobuccal rotation of the banded tooth. Note that this rotation is a favorable movement in the correction of a Class II molar relationship. **B,** Load activation curve of the quad-helix appliance illustrates an 8 mm. activation prior to cementation creates approximately 14 ounces of force.

as a midline discrepancy. This child had a history of a prolonged thumb-sucking habit. The lowered tongue position and the extreme forces created by the buccinator muscles produced a narrow maxilla. The net effect of the abnormal muscle forces created the dental problem illustrated in Fig. 3, *B*. Fig. 3, *C* shows the quad-helix appliance on the pretreatment model prior to placement on the deciduous second molars.

The appliance is activated approximately 8 mm., or the buccolingual width of an average deciduous second molar. This is generally sufficient activation to produce the desired maxillary expansion in the majority of the cases. Because of the palatal position of the quad-helix appliance, an added effect is that it often acts as a habit-breaking device for patients with a prolonged thumb-sucking habit. It is relatively comfortable for the patient, it rarely affects normal speech, and

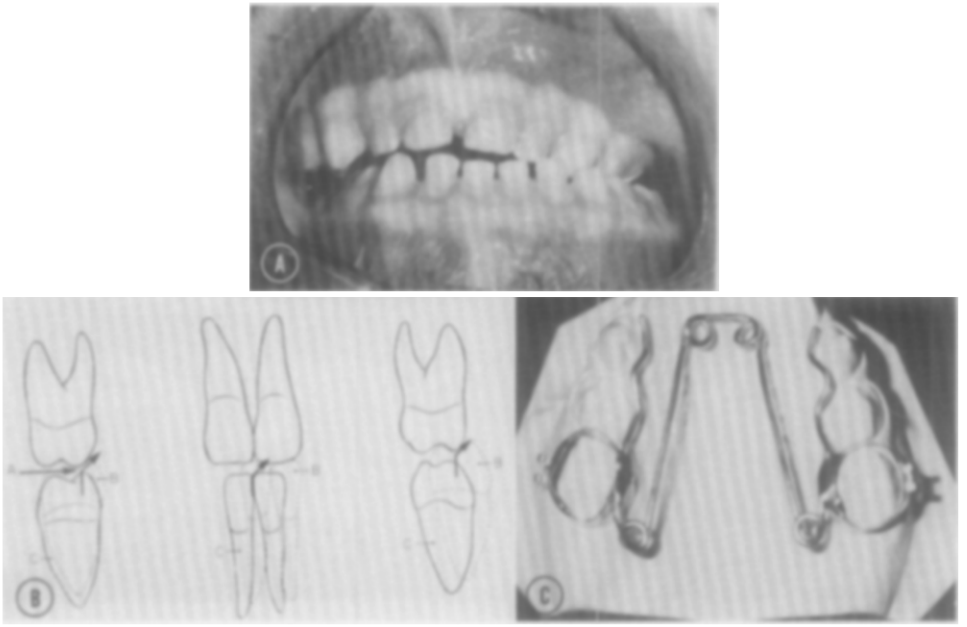

Fig. 3. Functional cross-bite due to narrow maxilla causes the mandible to shift to one side in order to occlude. **A,** Five-year-old patient with an "apparent" cross-bite in the left posterior segment. Note mandibular midline in relation to the upper. **B,** The apparent "normal" occlusion **(A)** is created by the patient shifting the mandible to one side, producing a functional cross-bite **(B)**. The resting position **(C)** reveals the bilateral nature of the maxillomandibular discrepancy. **C,** Quad-helix appliance constructed for the treatment of the narrow maxilla, prior to cementation. Note contour of lateral arms to conform to curvature of deciduous canines and first molars. Maxillary premolar bands are used on the deciduous second molars. Buccal attachments are used for easy placement of band into impression for working model.

it does not cause the unpleasant pressures associated with the rapid jackscrew palate-splitting devices. Fig. 4 shows the dentition in various stages of development as well as the pre- and posttreatment models illustrating the amount of expansion produced.

Orthodontic considerations

The quad-helix appliance does not produce sufficient force to create an orthopedic effect on the maxilla of an adult patient. The magnitude of force is in the tooth-movement range and acts to expand dental units in a collapsed arch. Figs. 5, *A* and 6, *A* and *B* illustrate the "mutilated" occlusion of an adult patient who suffered from a relapse of previous orthodontic treatment. It was determined that, besides the crowding, both arches were abnormally narrow and could be expanded to a more normal position. From previous studies conducted by Gardner and Chaconas,[7] it was decided that certain areas of the dental arch can be expanded with a stable result. Fig. 5, *B* illustrates the quad-helix appliance placed for the initial expansion and prior to the diagnostic model setup to determine if extraction of teeth was necessary.

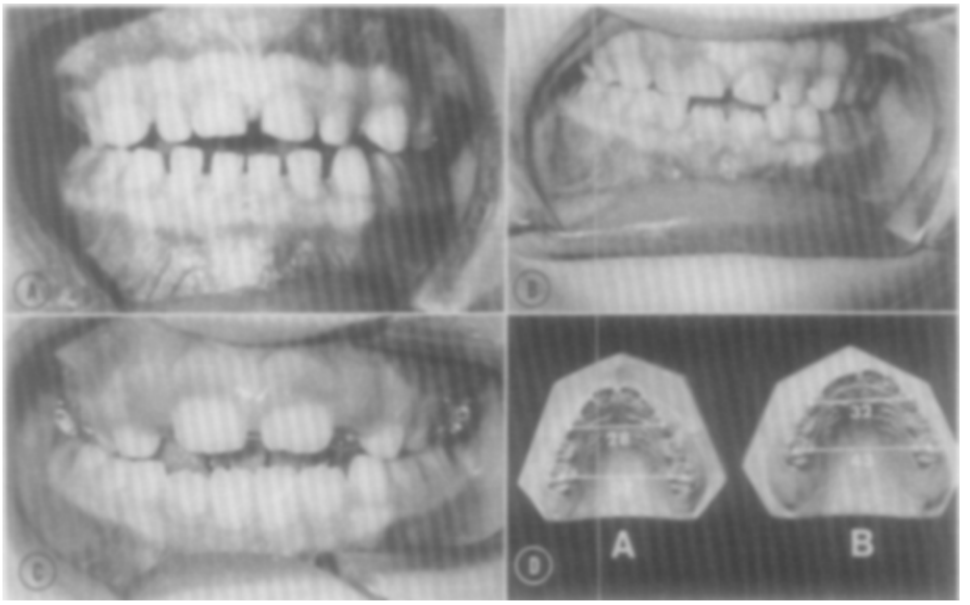

Fig. 4. Results of treatment to correct narrow maxilla and mandibular displacement in the deciduous dentition. **A,** Occlusion after 3 months of treatment with the quad-helix appliance. **B,** After 6 months the appliance was removed. Note midline correction. **C,** Approximately 1 year after the onset of treatment. A tongue crib is often used as a "retainer" to stabilize correction and to prevent a recurrence of the anterior open-bite during the eruption of the permanent incisors. **D,** Before **(A)** and after **(B)** treatment models. Note amount of expansion, in millimeters, produced in the canine and molar areas.

Since light forces are required to move teeth, it has often been advocated that the appliance be adjusted periodically, rather than initially expanded as was described previously, when orthopedic results are possible. Intraoral adjustments to the anterior bridge and inner arms, as indicated in the top part of Fig. 7, however, were shown to cause an incremental decrease from the original force placed in the appliance.[5] Therefore, for better control of the expansion forces placed on adult teeth in this critical movement, the appliance should be removed periodically and tested to determine the force magnitude.

Fig. 5, *C* illustrates the maxillary expansion that took place after approximately 4 months of treatment with the quad-helix. When it was determined that sufficient maxillary expansion had resulted, diagnostic casts were made to determine the proposed treatment plan. After several setup attempts, it was determined that the best treatment for this patient would include extraction of the other upper first premolar and another lower incisor. Figs. 5, *D* and 6, *C* and *D* represent the patient's occlusion 1 year after retention. The bottom part of Fig. 7 illustrates the upper models and the amount of expansion that took place during treatment.

Conclusion

A brief description of the evolution of maxillary expansion devices has been given, with examples of how a particular one can be used in both the deciduous

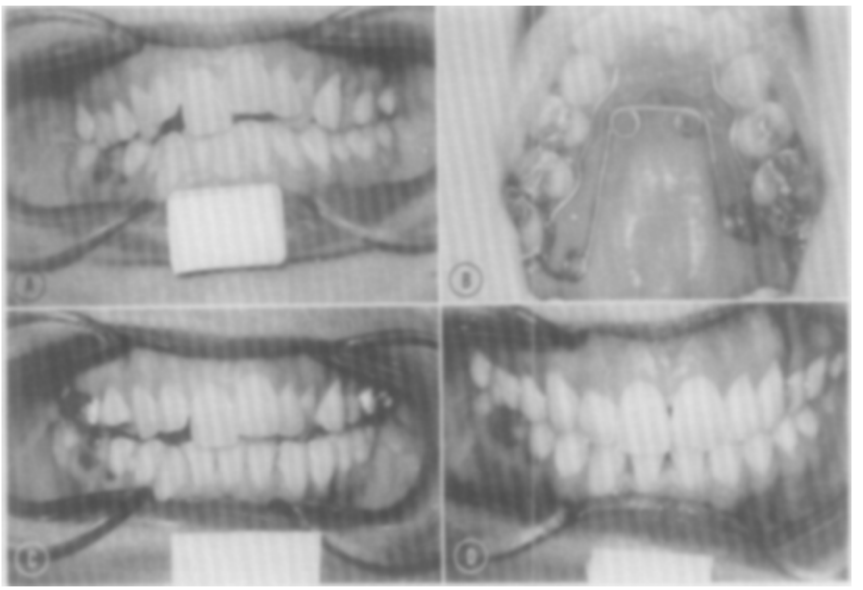

Fig. 5. Use of the quad-helix appliance for the correction of a collapsed dental arch in an adult. **A,** Occlusion of a relapsed orthodontic result. Note narrow maxillary intercanine width, anterior crowding, and missing lower incisor. **B,** Quad-helix appliance placed in an adult to produce expansion of a collapsed dental arch. **C,** Maxillary expansion after 4 months of quad-helix treatment and prior to full-banded edgewise appliance. **C,** Occlusion of patient after 14 months of full treatment, 1 year of retention, and 1 year out of retention.

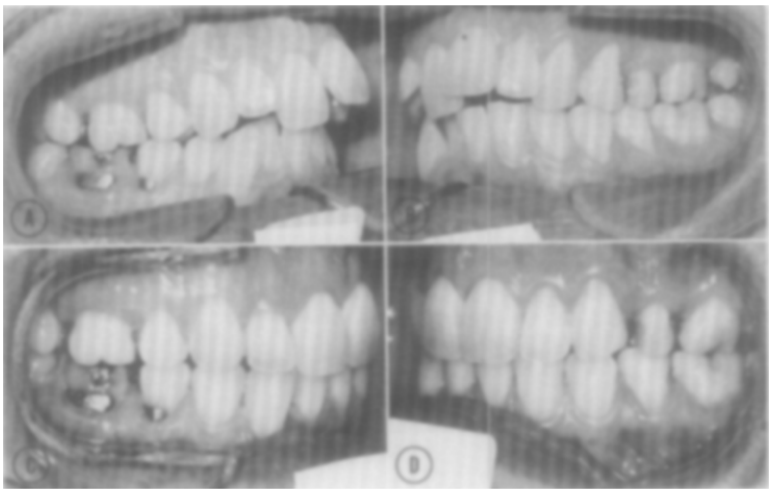

Fig. 6. A and **B,** Posterior occlusion of adult patient prior to maxillary expansion with quad-helix appliance and full-banded treatment. Note absence of maxillary right first premolar which was extracted during earlier treatment which had relapsed. **C** and **D,** Occlusion of patient after 14 months of full treatment, 1 year of retention, and 1 year out of retention. Treatment required the extraction of a lower incisor and the maxillary left first premolar.

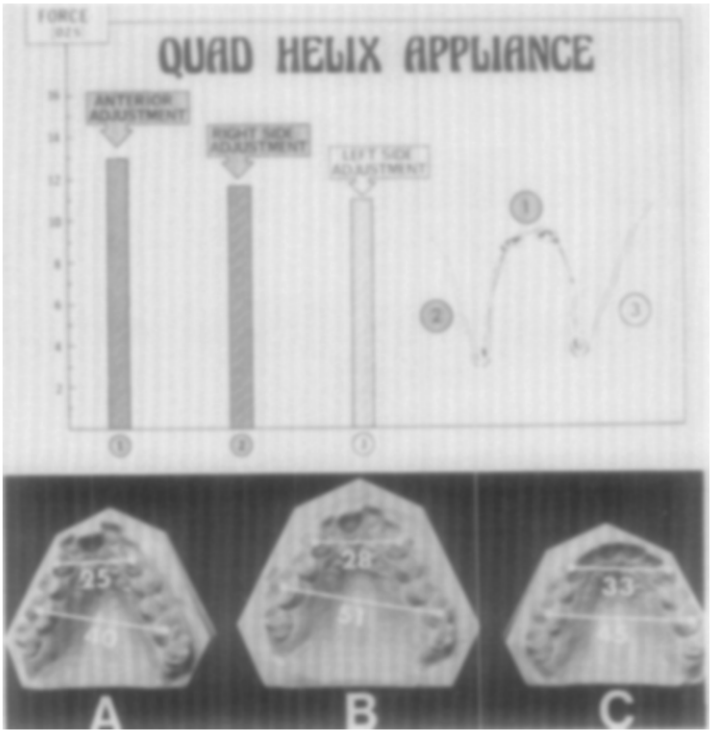

Fig. 7. Top: Intraoral adjustments to anterior bridge (**1**) and inner arms (**2** and **3**) are often advocated. However, each intraoral adjustment produces an incremental decrease in the force originally placed in the appliance. **Bottom:** Before (**A**) and after (**B**) quad-helix expansion treatment of adult patient. Right cast (**C**) represents the maxillary arch 1 year after retention. Increase of intercanine width from **B** to **C** was due to left canine retraction. Reduction of intermolar width during the same period was caused by advancement of left molar.

and the adult dentitions. Orthopedic and orthodontic effects can be produced by means of the quad-helix appliance with equally satisfactory results.

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