OVERVIEW

Orthodontic Retention and Stability: A Clinical Perspective

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(Editor's Note: In this quarterly column, JCO provides a brief overview of a clinical topic of interest to orthodontists. Contributions and suggestions for future subjects are welcome.)

Our concerns about the stability of orthodontic treatment still seem to be the same as those expressed by Calvin Case in 1920: "If there is one part of orthodontia more than another that is absolutely indispensable to the success of this specialty and its establishment upon a firm foundation as one of the arts and sciences, it is the permanent retention of regulated teeth. . . . what does this temporary pleasure and satisfaction to ourselves and our patients amount to, if we find in a few years that the very cases which create in us the greatest pride, are going back to their former malpositions and disharmonies, in spite of everything we have been able to do with retaining appliances."[1]

Vanarsdall and White summed up the problem as follows: "Early in the development of orthodontics, a serious misconception evolved. Dentists and the public were led to believe that orthodontic treatment could result in teeth that were straight for a lifetime."[2] Citing a friend, Hawley said, "If anyone would take my cases when they are finished, retain them and be responsible for them afterward, I would gladly give him half the fee."[3] As Case pointed out, retention is difficult precisely because of the uncertainty of orthodontic stability.

Based on the five randomized clinical trials (RCTs) that met their inclusion criteria, a recent systematic review by Littlewood and colleagues failed to establish any reliable guidelines regarding the efficacy of various retention protocols.[4] Dietrich has argued that "the conduct of high-quality RCTs may not be a realistic goal for many dental interventions and procedures. Well-designed observational studies may be a viable, cost-efficient alternative."[5] Likewise, Keim[6] and Williams and Garner[7] have challenged the idea that valid orthodontic research can be achieved only through evidence-based systematic reviews.

Considering the lack of suitable systematic

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reviews (model 1) in the area of retention and stability, this article presents a clinically relevant evidence-based perspective (model 2 in Ismail and Bader's hierarchy of best evidence).[8]

Retention for Life

Based on extensive research conducted at the University of Washington, Little and colleagues concluded that orthodontic results are more likely to be unstable than to be stable.[9] In these authors' opinion, the only way to ensure continued satisfactory alignment after treatment would be to provide retention for life.

In a recent, comprehensive review of the orthodontic literature regarding relapse, Shah found that postretention relapse of the mandibular incisors was often incorrectly attributed to misdiagnosis, improper treatment, or inappropriate treatment mechanics.[10] Mandibular incisor relapse is almost inevitable, he pointed out, regardless of the timing of orthodontic treatment and the techniques employed. Even the extraction of premolars to alleviate crowding does not appear to make corrections any more stable.[11-13]

Arch Perimeter and Intercanine Width

The main reason for a relapse of crowding is the tendency for dental arch perimeter or length and intercanine width to decrease and constrict over time. This pattern has been found in treated as well as untreated normal subjects[14]; in fact, as early as 1959, Moorrees demonstrated a reduction in arch length from the mixed dentition through the transitional dentition and into early adulthood.[15]

Gianelly[16,17] and others[18-21] have argued that the stability of orthodontic treatment can be improved by preserving mandibular intercanine width. This means that any increase in mandibular intercanine dimension is inherently unstable.[18,20,22,23] Along the same lines, Blake and Bibby listed six major criteria for the stability of finished orthodontic cases[24]:

1. The patient's pretreatment lower archform should be maintained to the extent possible.
2. The original lower intercanine width should be maintained as much as possible, because expansion of lower intercanine width leads to the most predictable of all orthodontic relapse.
3. Mandibular arch length decreases with time.
4. The most stable position of the lower incisor is its pretreatment position; advancing the lower incisors can seriously compromise stability.
5. Fiberotomy is an effective means of reducing rotational relapse.
6. Lower incisor reproximation can improve long-term post-treatment stability.

Circumferential Supracrestal Fiberotomy and Interproximal Force

Edwards found circumferential supracrestal fiberotomy (CSF) somewhat more effective in preventing pure rotational relapse than in reducing labiolingual relapse over the long term, and more successful in the maxillary anterior segment than in the mandibular anterior segment.[25] Significant and unpredictable individual tooth movements were still observed after CSF. Reorganization of the periodontal ligament occurs over a three-to-four-month period,[26,27] whereas the gingival collagen-fiber network typically takes four to six months to remodel, and the elastic supracrestal fibers remain deviated for more than 232 days.[28]

A continuous, compressive interproximal force (IPF), originating in the periodontium and acting on adjacent teeth at their contact points, may be responsible for some long-term arch constriction.[29] Southard and colleagues found a significant correlation between mandibular anterior malalignment and IPF.[30] It has been suggested that if IPF does have an influence on dental alignment, it probably acts in conjunction with lip and cheek forces to collapse the arch. These forces are opposed by the tongue, which tends to expand the arch.

It follows that the influence of IPF should be more evident in the anterior segment of the arch, where the contact points are narrower, the crowns more tapered, and the expansive force of the tongue more intermittent than in the posterior regions. Perhaps for this reason, lower incisor reproximation can counteract IPF by slightly narrowing the teeth and by broadening their contacts to resist

contact slippage.

Boese found an improvement in post-treatment stability of the mandibular anterior segment, without retention, when fiberotomy and reproximation were used in combination with overcorrection and selective root torque.[31] This protocol often included serial post-treatment reproximation. Boese's cases all involved extractions, however, and the impact of individual treatment variables could not be isolated.

The effect of the amount and structure of mandibular bone on mandibular incisor stability has recently been investigated in a case-control study at the University of Washington.[32] After measuring trabecular bone structure and cortical bone thickness in both relapsed and stable subjects, Rothe concluded that patients with thinner mandibular cortices are at increased risk of dental relapse.

Third Molars and Mandibular Incisor Relapse

The justification often given for extraction of third molars at age 18 to 22 is the avoidance of mandibular incisor relapse and irregularity. Southard[33] and others[34] have argued against the prophylactic extraction of disease-free third molars, however, for the sole purpose of relieving interdental pressure and preventing anterior crowding. In this view, orthodontic retention may be more efficacious and cost-effective than third molar extractions.

Silvestri and Singh contended that the morbidity data supporting third molar removal are suspect because most studies have been short-term, retrospective, and cross-sectional, focusing on radiographic evidence of disease with little or no histopathologic support.[35] Furthermore, the prophylactic extraction of many asymptomatic, disease-free impacted third molars early in life makes it difficult to assess morbidity.[35] It has even been suggested that surgical extraction of third molars can increase the risk of developing future TMD symptoms.[36]

On one hand, the National Health Service of Great Britain has terminated payment for elective third molar extractions; on the other hand, Assael has argued that the overwhelming majority of third molars warrant removal.[37] As a result of a recent systematic review, however, the Cochrane group has taken a conservative view.[38] Based on the only three trials that met their selection criteria, two of which were RCTs, they found no evidence to either support or reject routine prophylactic removal of asymptomatic impacted third molars in adults.

There may still be cases in which asymptomatic adults need their third molars removed. One indication is the presence of periodontal pockets between the second and third molars. Blakey and colleagues reported that in 38% of their subjects with pocket depths of greater than 4mm at the beginning of the study, the pockets worsened over time.[39]

Retention Appliances

Fixed Retainers

For fixed, semipermanent retention in either arch, an .0175" twisted, flexible wire can be bond-

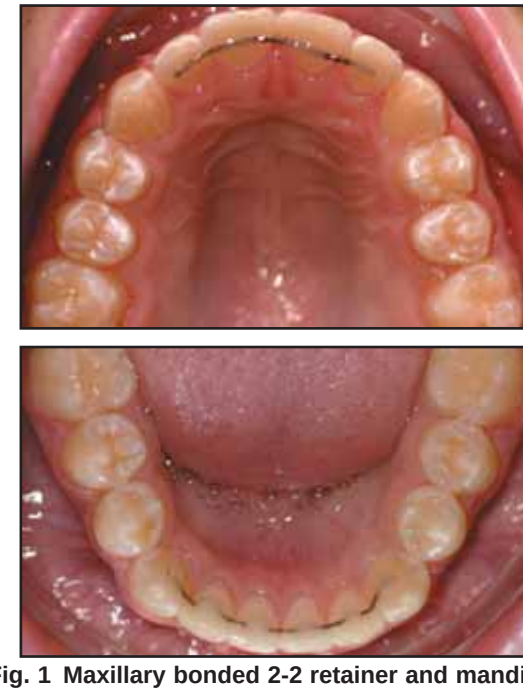

Fig. 1 Maxillary bonded 2-2 retainer and mandibular bonded 3-3 retainer.

ed to every anterior tooth (Fig. 1). With a rigid wire bonded only to the canines, some labial movement or rotation of the incisors may occur. The flexible wire should be heat-treated to dead soft to remove its shape memory, so that the terminal teeth will not move facially as the wire ends straighten. Removable retainers can be fabricated to fit over these bonded wires if desired.

Fixed retainers can be placed with conventional composites, although it is easier to use less viscous retainer composite adhesives or flowable restorative composites. If a maxillary bonded retainer is used to help control alignment or keep spaces from reopening, a more heavily filled composite may be needed to resist occlusal forces. A thick upper bonded retainer also has a biteplane effect, which helps maintain the overbite correction. A restorative posterior composite build-up is recommended to help withstand the occlusal load over time. If the bonded retainer interferes with occlusion and mandibular function, Topouzelis and Diamantidou recommend cutting a groove in the lingual surfaces of the maxillary anterior teeth, so that the retainer wire can be bonded without causing interference.[40]

Woven, plasma-treated polyethylene ribbon-reinforced material has been recommended as an alternative to multistranded wires in fixed retention. In a prospective study, however, Rose and colleagues concluded that multistranded wire was superior to the ribbon composite when bonded from canine to canine.[41]

The consequences of long-term fixed retainer wear have been a concern. Over a six-month retention period, Heier and colleagues found limited gingival inflammation with either Hawley-type removable or bonded lingual retainers.[42] Although they noted slightly more plaque and calculus on the lingual surfaces in the fixed retainer group, this did not result in more significant gingival inflammation. In a longer-term study, Årtun showed that the presence of a bonded lingual retainer for as long as eight years and the occasional accumulation of plaque and calculus gingival to the retainer wire caused no apparent damage to the hard and soft tissues.[43]

Advantages: Some authors have contended that a patient with reduced periodontal support may be better off with a fixed retainer.[40,44-46] A removable retainer may produce "jiggling" forces that can compromise healing and bone regeneration, whereas a fixed retainer can serve as a periodontal splint. In addition, there is no patient compliance issue with a fixed retainer, and minor settling of the posterior occlusion can occur.

Disadvantages: The patient is obviously responsible for cleaning the teeth and the retainer, but who takes responsibility if a fixed retainer breaks and the teeth subsequently relapse? A bonded wire retainer can also be distorted by occlusal or outside forces. The patient may not know that the bonding has been compromised, and relapse, decalcification, or caries may result. If the patient cannot wear a fixed retainer permanently, a removable appliance is the only alternative for lifetime retention.

Fig. 2 Hawley retainer with C-clasps around maxillary second molars.

Removable Hawley-Type Retainers

The Hawley-style retainer is still commonly used in the upper arch. To enhance mechanical retention, acrylic can be added to the labial bow from canine to canine.

Advantages: Sauget and colleagues noted that a traditional Hawley retainer allows settling, and thus an improvement in posterior occlusal contacts, compared to full-coverage thermoplastic

retainers.[47] Furthermore, a Hawley is quite durable, some lasting longer than 15 years in our practices.

Disadvantages: Settling cannot occur where wires cross the occlusion, and iatrogenic problems may arise in these areas. There is often sufficient clearance for a crossover wire between the canine and premolar, however, and the posterior wire can be fabricated as a distally approaching ring or C-clasp rather than an Adams clasp to avoid occlusal interference (Fig. 2). An alternative design is the Begg-style wraparound retainer with the labial bow crossing distal to the molars. Thin stabilizing wires can be added in the anterior region to keep the labial section from moving vertically, incisally, or gingivally.

Of course, compliance is always a concern with removable appliances. In addition, contrary to expectation, removable retainers may actually be less hygienic than bonded ones. There is some evidence to suggest that removable partial dentures can promote plaque accumulation.[48,49]

Removable Thermoplastic Retainers

Thermoplastic retainers are generally made from two classes of material: copolyester (Essix type "A",* Endure**) and polypropylene or ethylene copolymer (Essix type "C+",* Duraforce***). An attachment such as a button can be bonded with acrylic to a type "A" retainer (Fig. 3), but not to the more robust type "C+" material. The procedure for bonding an attachment is to roughen the area to be bonded; apply a monomer acrylic to the area, and let it stand for two to five minutes; reapply the monomer; place the acrylic on the attachment, and cure it either chemically or with a light source; and let the retainer set for 30 minutes.

Type "A" materials are generally more esthetic because of better clarity, but have a propensity to tear and crack (Fig. 4). Type "C+" materials are sturdier, but their mechanical retention is not as good. Manufacturers are creating a new generation of thermoplastic materials, including ACE* and Duraclear,*** in an attempt to combine the benefits of the "A" and "C+" materials: durability, retention, clarity, and bondability to acrylic. In our experience, however, these new materials are not durable, tend to crack easily, and discolor rapidly with use (Fig. 5).

In a master's thesis under Dr. Sheridan's supervision, Butler measured the stability of ortho-

Fig. 3 Type "A" thermoplastic material with bonded metal attachment for elastics.

Fig. 4 Fragility of type "A" plastic evidenced by torn and cracked thermoplastic retainers.

*Raintree Essix, Inc., 4001 Division St., Metairie, LA 70002; www.essix.com. Essix is a registered trademark.

**Registered trademark of Great Lakes Orthodontics, 200 Cooper Ave., Tonawanda, NY 14150; www.greatlakesortho.com.

***Glenroe, 1912 44th Ave. W., Bradenton, FL 34203; www.glenroe.com.

dontic results over the first nine months after the delivery of removable Hawley retainers.[50] Full-time wear was compared to night-only wear in both extraction and nonextraction cases. Sixty percent of the full-time patients lost or broke their retainers, as opposed to only 13% of the night-only patients. There were no significant differences between the two groups in any of the retention parameters, including incisal stability, canine width, arch length, and molar width.

In a study by Lindauer and Shoff at the Medical College of Virginia, 56 patients were randomly assigned to Essix and Hawley retention groups.[51] The patients in the Essix group were instructed to wear their mandibular retainers full-time and their maxillary retainers half-time for the first four weeks, and both retainers only at night thereafter. The thermoplastic retainers were as effective as the Hawley retainers in maintaining orthodontic corrections, and there was no incidence of anterior open bite in the Essix group.

In a prospective RCT of 389 patients, Rowland and Williams found after six months that more incisor irregularity occurred in the group with Hawley retainers than in the group with vacuum-formed thermoplastic retainers.[52] In a parallel study, 53 subjects were less satisfied with their Hawley retainers than with thermoplastic retainers in terms of speech and esthetics.[53] Moreover, thermoplastic retainers were considered more cost-effective in controlling irregularity.

Advantages: The major advantages of thermoplastic retainers are that the responsibility for retention resides with the patient, and that minor tooth movements can still be performed.[54-57] When worn only at night or part-time, canine-to-canine thermoplastic retainers maintain the esthetics of the anterior teeth without causing anterior open bite. They allow the buccal segments not only to settle, but to adapt to diet, lifestyle, aging, and stress. A 3-3 Essix retainer should last as long as two years—perhaps longer if the patient, like most of us, sleeps with the mouth ajar. Likewise, we have found that Duraforce retainers are both effective and durable, especially when worn canine to canine.

Because these retainers are clear and nearly invisible, many patients prefer them to conventional Hawley devices, whose esthetics and comfort may be compromised by acrylic and metal. The inexpensive thermoplastic retainers can also be used as habit appliances, molar-uprighting appliances, bleaching trays, space maintainers, and biteplanes.[55]

Disadvantages: Like other removable retainers, thermoplastic devices rely on patient compliance. Because their material is not as durable as a Hawley-type retainer, more replacements are needed. Finally, thermoplastic retainers do not allow occlusal settling if they are extended back to the molars.

Fig. 5 Although type "C+" thermoplastic materials are more robust than type "A", we have experienced cracking and discoloration with prototype materials that combine properties of both types. Note dark gray discoloration of these retainers, worn for only six months, due to leaching of patient's amalgam restorations into thermoplastic material.

Combinations of Removable and Fixed Retainers

A Hawley-style upper retainer with labial acrylic coverage to control rotations and distally approaching C-clasps rather than Adams clasps is an excellent all-purpose upper retainer that allows minor occlusal settling. Since the lower arch is more prone to relapse, a fixed retainer bonded to every anterior tooth reduces this risk.

In Class II, division 2 treatment or a case with substantial maxillary anterior rotations, a bonded upper retainer may also be desirable. For added security and long-term retention, a thermoplastic retainer can be fitted over the bonded wire for night-time wear.

Bonded retainers can be left in place for a predetermined period of one to two years, then replaced by removable retainers. In a deep-bite case, a thermoplastic upper 3-3 retainer may help maintain the overbite and prevent relapse of the overbite. Conversely, an open-bite patient may need a lower Hawley-style retainer; if a thermoplastic type is used, all teeth should be incorporated, with occlusal coverage to minimize the risk of bite opening during retention.

Conclusion

We believe it is prudent to establish a retention protocol based on the needs and concerns of each individual patient. With conflicting views and a lack of scientific evidence regarding the causes of relapse, the most predictable and cost-effective way to ensure the stability of orthodontic treatment is probably a lifetime of retainer wear. Therefore, patient cooperation is of the utmost importance. With this goal in mind, we have our patients (even minor children) and parents sign both pretreatment and post-treatment agreements acknowledging that they will have to wear retainers for an extended period of time—a lifetime. Our patients thus share the responsibility with us for keeping their teeth straight.

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