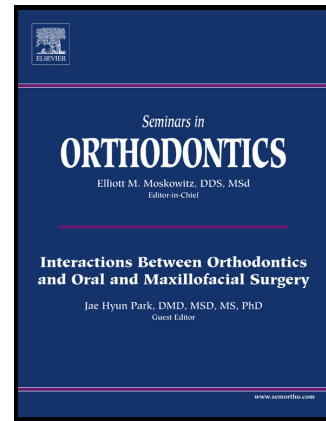


Author's Accepted Manuscript

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www.elsevier.com/locate/ysodo

PII: S1073-8746(16)30091-3

DOI: <http://dx.doi.org/10.1053/j.sodo.2016.12.011>

Reference: YSODO497

To appear in: *Seminars in Orthodontics*

Cite this article as: P. Emile Rossouw and Shaima Malik, The retention protocol, *Seminars in Orthodontics*, <http://dx.doi.org/10.1053/j.sodo.2016.12.011>

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The Retention Protocol

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Abstract:

This article was completed following communication with a number of well-established and experienced orthodontists, including well-respected academicians, from around the world (see acknowledgements at end). Post-treatment irregularity observations were put in perspective with those factors generally known about retention.

“It is not so difficult to straighten crooked teeth, to get the dental system into a position acceptable to your patients and yourself, but to hold it there until it becomes permanently settled, is a much more serious problem. It is the one important consideration in all your prognosis, and the success of orthodontia as a science and as art lies in the [retainer].... Do not discharge the case or abandon retainers until there is a reasonable expectation of permanence. You may rightfully ask of that experience; how long will that be? Your patient will pester you with the same query. Out of the same observation and experience I can only answer, I don't know”.

- Norman Kingsley (1908).

Retention planning at the beginning of treatment and the continued focus during treatment

Most clinicians agree that retention should be considered right from the beginning of diagnosis and treatment planning. In so doing the potential factors considered for long-term stability will be kept in mind throughout treatment. Moreover, as important is the orthodontic biomechanical objectives of tooth movement in the craniofacial environment. Setting goals early also aids retention considerations during the process of active orthodontic treatment.¹

It is imperative that patient expectations are established at the outset of treatment. After fixed appliance orthodontic treatment, retainers are routinely fitted by the orthodontist and are worn by the patient for at least 6 to 12 months while the soft and hard tissues remodel around the teeth.² Al Yami et al (1999),³ studied the stability of orthodontic treatment after 10 years post-retention. They evaluated dental casts of 1016 patients to determine the long-term treatment outcome using

the Peer Assessment Rating (PAR) index. The PAR index was measured at the pretreatment stage, directly post-treatment, post-retention, 2 years post-retention, 5 years post-retention, and 10 years post-retention. The results indicate that 67% of the achieved orthodontic treatment result was maintained 10 years post-retention. About half of the total relapse (as measured with the PAR index) takes place in the first 2 years after retention. All occlusal traits relapsed gradually over time but remained stable from 5 years post-retention with the exception of the lower anterior contact point displacement, which showed a fast and continuous increase even exceeding the initial score. The results of this type of studies enable clinicians to inform their patients about treatment limitations in order to better meet their expectations.

Long-term observations of untreated and treated dentitions have provided factors, occlusal keys,⁴⁻⁶ hypotheses and theorems,⁷ to consider in the pursuit to a physiologic stable occlusion.¹ Factors requiring consideration during treatment include lower incisor alignment, correction of rotations of anterior teeth, changes in the anteroposterior lower incisor position, correction of deep overbite, correction of anterior open bites, patients with a history of periodontal disease or root resorption, growth modification treatment, correction of posterior and anterior cross bites, adult patients with often their mutilated occlusions and spaced dentitions. Thus, treatment planning with retention in mind is imperative for ultimate success.

Treatment planning should take the following in consideration:

- i.** The impact of etiological factors on malocclusion has been well documented in the literature.^{7,8,9,10,11,12} Eliminate these factors as soon as possible. Also, maintain a healthy periodontal environment as periodontal breakdown has possible long-term stability consequences.
- ii.** Teeth that have been moved tend to return to their former positions:⁷ studies assessing the changes that occur following the treatment show to a minor or major extent that the teeth have a tendency to undergo rebound or settling changes. Minor changes fall into the category of physiologic stability^{13,14} and unacceptable changes can be considered as relapse. It is fortunate for the clinician to note that these changes appear to decrease in tempo with age.¹⁵
- iii.** If the lower incisors are planned to be upright over basal bone, they are more likely to

remain in good alignment.^{16,17} Moreover, if there is any tendency for teeth to return to their original positions and in this instance, a tendency to procline slightly, additional space, albeit minor, will be created to assist in maintenance of the tooth alignment.¹⁷

- iv. Lower incisor position in respect to the Point A - Pogonion (Apo) line:^{6,18} The incisal edge of the lower incisor should be placed on the APo line or 1 mm in front of it as recommended by Ricketts (1 ± 2 mm). This recommendation is the optimum position for lower incisor stability.¹⁸ It also creates, according to Williams,¹⁹ optimum balance of soft tissues in the lower third of the face for all the variations in apical base differences within the normal range. Appliance control is required to achieve optimal positioning of the lower incisor at the end of treatment as shown by Williams and Hosila²⁰ and Woodside et al.²¹ This is especially important in contemporary orthodontics, as we practice clinical orthodontics in an era where prescription appliances are used as the norm. It is thus imperative to treat each patient as a unique individual as all prescriptions may not be appropriate for all, the same as we do not all wear the same size shoes. It is proposed that if the lower incisor is advanced too far beyond the APo line, relapse and crowding will occur. Lower incisors that are overly proclined in treatment (beyond one standard deviation) can only be maintained in such a position with a fixed retainer. The incisors will move lingually and become crowded when the retainer is removed according to Mills.^{22,23} Lower incisor position also dictates when teeth need to be extracted and which ones would be ideal. Moreover, a literature review by Blake and Bibby,²⁴ showed that the most stable positions of the teeth are their pretreatment positions.
- v. The mesiodistal inclination of the lower incisor or second-order position: The lower incisor apices should be positioned distally to the crowns more than is generally considered appropriate, and the apices of the lower lateral incisors must be more than those of the central incisors.^{4,6} Modern day appliances have this tip (second-order prescription) included in the design of the appliances. When the lower incisor roots are left convergent, or even parallel, the teeth tend to become irregular again following treatment as a natural phenomenon of uprighting; that is, roots distal to crowns, according to Andrews.^{4,5} In addition, the contact points are higher in this situation. A fixed lower retainer is usually needed to prevent such posttreatment relapse.

vi. Lower cuspid inclination (mesiodistal/second order) and angulation (labiolingual/third order) position: similarly, to the incisors, the apex of the lower cuspid should be positioned distal to the crown. Williams⁶ recommends the occlusal plane, rather than the mandibular plane as reference line for this assessment. This angulation of the lower cuspid is important in creating posttreatment incisor stability because it reduces the tendency of the cuspid crown to tip forward into the incisor area. Distal inclination of the lower cuspid should be a standard treatment objective. Straight-wire systems incorporate this cuspid inclination. The lower cuspid root apex must also be positioned slightly buccal to the crown apex. This is an extremely important third order prescription because of its influence on post-treatment stability. Occlusal forces exert lingual pressure on the lower cuspid crown and if the apex of the lower cuspid is lingual to the crown at the end of treatment (uncontrolled expansion and buccal tipping), the forces of occlusion can more easily move the crown lingually towards the space reserved for the lower incisors because of these functional pressures plus a natural tendency for the crown to upright over its root apex. It was previously shown that the intercanine dimension appears to decrease over the long term. Even if a lower cuspid with an abnormal lingual position of the apex were supported for many years with a fixed retainer, the crown would eventually move lingually when the retainer was removed, resulting in delayed relapse.^{6, 21, 25, 26, 27}

vii. Alignment of the incisor incisal edges are often mistaken for adequate incisor alignment. Great care must be exercised to align also the apices of the incisors mesiodistally and labiolingually. All four lower incisor apices must be in the same labiolingual plane according to Williams (1985).⁶ The distal positioning of the apices of the lower incisor roots results in a reciprocal tendency for the crowns to move mesially. This strong mesial pressure on the crowns during the root positioning process (care must be taken with this positioning as the tooth takes up more space in this manner) easily leads to incisor irregularity due to the contact point displacement labiolingually. This results in a reverse movement of the apices linguolabially. Additional space is required for these movements to ensure stability, otherwise the labiolingual apical displacement of the lower incisors and noted subsequent lower incisor posttreatment irregularity will be established. This again emphasizes the meticulous management of the appliance;^{20,21,27,28} moreover, keep in mind that rectangular archwires control these movements more efficiently than round wires.

- viii.** Interproximal contact of the lower incisors often require slenderizing as the mandibular arch length shows a continued decrease over time.^{15,25} This is a biologic occurrence in both treated and untreated dentitions, which ultimately results in an outcome of slipping contacts or an increase in tooth irregularity. This is one factor in the Anterior Component of Force, which with others, such as growth pattern, mandibular plane angle, forward inclination of teeth and forward driving occlusal forces to name some, all collectively facilitate lower incisor crowding or irregularity. The lower incisors should be slenderized as needed after treatment to release tight contacts or any tooth-size discrepancies.^{6,29} Lower incisors that have sustained no proximal wear have round, small contact points, which are accentuated if the apices have been diverged for stability. Consequently, the slightest amount of continuous mesial pressure can cause various degrees of contact slippage in either buccal or lingual direction in the lower incisor segment. This Anterior Component of Force described by Southard et al³⁰ contribute to this continuous tendency of teeth to move forwards or mesially.
- ix.** Adverse tooth–jaw relationship is another possible factor in posttreatment changes. This is especially true in extraction treatment; the removal of two, four or more teeth may not provide the perfect solution for tooth-size–jaw-size discrepancy, and it is conceivable that the right combination to provide balance and stability in some instances should be the partial removal of teeth; that is 1¾ teeth when two are required for extraction or 3¾ teeth when four teeth need to be extracted.⁶ Thus, interproximal enamel reduction is essential to facilitate this balance.
- x.** Malocclusion should be overcorrected as a safety factor.⁷ It is preferable to treat and let the posttreatment changes occur in favor of the norm; thus such parameters as overbite and overjet illustrate this phenomenon well.²⁵ The over corrected overbite and overjet allow posttreatment settling to occur towards the normal clinical values described. This goal is also pursued for, especially, the transverse dimension.^{31,32}
- xi.** Proper interdigitation of the teeth as defined by the Andrews six keys to a normal occlusion.^{4,5} Proper occlusion is a potent factor in holding teeth in their corrected positions³³ and is one of the classic theorems of stability.⁷ Pancherz³⁴ also recommended this factor as a facilitator of long-term stability. He observed Herbst treatment in the correction of Class II

malocclusions for many years and concluded that a well-established interdigitated occlusion post treatment provided long-term stability of the treated result.

- xii.** Maintain the original archform. ^{7,25,33} It is professed that the mandibular arch, in particular, cannot be permanently altered by appliance therapy. It is generally agreed that arch form and width should be maintained during orthodontic treatment and in certain cases, where arch development has occurred under adverse environmental conditions, arch expansion as a treatment goal may be tolerated. Studies by Welch in 1956, ³⁵ Amott in 1962, ³⁶ Arnold in 1963, ³⁷ and Kahl-Nieke in 1995, ³⁸ show the evidence that intercanine and intermolar widths decrease during the post-retention period, especially if expanded during treatment. For this reason, the maintenance of arch form rather than arch development is generally recommended. Moreover, according to growth studies, the basal transverse dimension in the anterior part of the mandible increases minimally after the age of 4 years and even less from 10 years to adulthood. ³⁹ Long-term studies of both treated and untreated malocclusions support this claim and have underlined the fact that the original intercanine width should be maintained as a continued decrease appears to occur in the long term. ^{25,33,40} The arch width increases and long-term stability was mostly in the posterior segments.
- xiii.** Time must be allowed for reorganization of hard and soft tissues: *Orthodontics is a “game of patience.”* Not all tissues react similarly at the same time; moreover, teeth move into new positions and then have to be maintained in order to allow time for the other tissues to “catch-up” with their reorganization. ^{2,7} Thilander ⁴¹ supported these changes in a publication on the biology of relapse. It is thus recommended that the teeth be aligned in their ultimate positions as a primary goal and then maintained (active retention) as a secondary goal through the treatment period.
- xiv.** Corrections carried out during periods of growth are less likely to relapse: ⁷ This classic theorem supports the controversial Phase 1 versus Phase 2 treatments. A net gain in arch width was shown in the long term following expansion during the mixed dentition followed by a second fixed appliance phase of treatment. ⁴⁰ Gianelly ⁴² reported in a publication on one-phase versus two-phase treatment that crowding can be resolved in 73% of patients in the mixed dentition stage of development, simply by preserving and using the Leeway space. This facilitates stability and retention as no need exists to surpass the natural borders of the

bony arches and soft tissues as adequate space was provided by this simple Phase 1 treatment procedure.

- xv. Mandibular backward rotation appears to influence long-term change: Long-term studies on stability mostly show that no single predictor for lower incisor stability exists; moreover, no significantly strong correlations could be established.^{1,28} However, few studies found that the vertical dimension could influence stability.^{10,12,25,43,44}

It is the end of treatment; what now?

Angle (1907) summarized orthodontic retention as the mechanical support of malpositioned teeth that have been moved into desired positions, until all the supportive tissues involved in the maintenance of these new positions have become thoroughly modified, both in structure and in function, to meet the new requirements.⁴⁵ Numerous factors impact the post-treatment result, hence, the importance of appropriate retention cannot be overemphasized to control the following:

- a. **Lower incisor alignment:** Changes in the antero-posterior lower incisor position, albeit intentionally or a non-intentional, change of more than 2mm indicates the need for long-term or indefinite retention according to Mills 1966 1967.^{1,46,47} With regard to long-term occlusal changes, irregularity is most marked in the mandibular labial segment.^{48,49} Increases in lower incisor irregularity occur throughout life in a large proportion of patients following orthodontic treatment and also in untreated subjects. Evidence suggests that most change will occur up to the second or third decade and then gradually reduce in tempo.^{15,50,51} Thus, prolonged retention of the lower labial segment until the end of facial growth may reduce the severity of lower incisor crowding.⁵² Patient expectations of the stability of their lower incisor alignment should be considered on completion of orthodontic treatment. If an individual is unwilling to accept any deterioration in lower incisor alignment following orthodontic treatment, then permanent fixed or removable retention may have to be considered.

- b. Corrected rotations of anterior teeth:** As the supracrestal gingival fibers are known to take the longest amount of time to reorganize, prolonged retention of corrected rotations may be helpful in reducing relapse. While the use of adjunctive circumferential supracrestal fiberotomy has been shown to be effective in reducing relapse within the first 4-6 years after debonding, the additional long term clinical benefit from the procedure is relatively small.⁵³
- c. Correction of deep overbite:** Following the correction of a very deep overbite the use of an anterior bite plane until the completion of facial growth has been recommended. This may be particularly useful when there is evidence of an anterior mandibular growth rotation.⁵⁴ Patients with an initially deep overbite had the deepest overbite 10 years post-retention, in addition, protrusion of incisors was correlated with overbite relapse, but was not related to whether or not extractions were performed.⁵⁵ It became apparent that occlusal plane changes during treatment tended to relapse to their original angulation, and this correlated with deep bite relapse.^{54,55} The conclusion was that mandibular growth, with a vertical component, was correlated with overbite stability.
- d. Curve of Spee:** An evaluation of the curve of Spee correction and its stability after treatment in Class II division 1 and Class II division 2 patients, including both extraction and non-extraction treatments, showed that patients with fixed retainers after treatment exhibited significantly less relapse than those with removable mandibular retainers.⁵⁶ This study found no relationship between skeletal measurements (FMA, ANB, PFH, LAFH) to curve of Spee relapse. This is in contrast to findings by Givins (1970),⁵⁷ who found more relapse in patients with low mandibular plane angles. No significant differences in curve of Spee relapse were found between Class I, Class II division 1, or Class II division 2 malocclusions and also between extraction and non-extraction groups. Patients with more second molar uprighting during treatment exhibited more curve relapse than those with less molar uprighting. The more the curve of Spee was leveled with treatment, the more it relapsed after treatment.

- e. **Correction of anterior open bites:** Treatment leading to counterclockwise rotation of the mandible may contribute to the stability of the overbite after treatment.⁵⁸ The use of retainers incorporating posterior bite-blocks have been recommended for prolonged retention of anterior open bite malocclusions with unfavorable growth patterns.⁵⁹
- f. **Correction of posterior and anterior crossbites:** When the incisor overbite and posterior inter-cuspatation are adequate for maintaining the correction, no retention seems necessary.
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- g. **Expansion:** Expansion through maxillary suture widening by rapid maxillary expanders has been claimed to promote stability after retention. Stability has been attributed to the skeletal component of arch enlargement obtained by the expansion appliance as opposed to dental expansion as a result of edgewise appliance mechanotherapy. Studies on immediate treatment effects of rapid palatal expansion have reported increases in arch width as a result of combined skeletal and dental expansion. Short-term follow-up has indicated a rebound effect of the dental component, yet a relative stability of the skeletal aspect of the expansion. The implant studies by Krebs in 1964⁶¹ during a 7-year observation period found a substantial reduction in dental arch width after discontinuation of retention which continued for as long as 4 to 5 years. Skieller in 1964⁶² carried out a scientific study where he inserted metal implants into thirteen girls and seven boys, using an expansion appliance. This was opened at the rate of 0.5 mm. per week for 7 months and then maintained for 12 months. He found that both the teeth and the vault widened and that the vault continued to widen both during retention and thereafter. The teeth, however, commenced to relapse at the end of the expansion and continued to do so out of retention, with the relapse amounting on average to about 25 percent of the total opening. Although he does not mention it, Skieller's, figures show that the dental relapse was less for the patients under 9 years old and noticeably higher for those over 12 years of age.⁶² Stockfish in 1969⁶³ found 50% of relapse within 3 to 5 years after retention after rapid palatal expansion. Linder-Aronson and Lindgren⁶⁴ performed a 5-year post-treatment study and noted that only 45% of the initially achieved rapid palatal expansion was maintained. They also found a residual expansion of 38%

and 59% for intercanine and intermolar widths, respectively, over a period of observation. Clinically, there appears to be no difference in the stability of surgically assisted rapid palatal expansion and nonsurgical orthopedic expansion.⁶⁵ The length of time after appliance removal in the latter study was slightly longer than a year. These patients were kept in retention during the 1-year period thus demonstrating the importance of retainers to control perioral forces and maintain stability. Both the orthopedic and the surgical groups showed stable results.

- h. *Adult versus adolescent patients:*** Growth tends to plateau as we grow older, but there still will be changes, example mandibular changes which often continues into adulthood. However, the faster tempo of growth experienced in the adolescent decreases as adulthood is reached with the adult showing a slower rate of change.^{15,55} It is important to be cognizant of these changes as retention should be continued at least until the decrease in tempo has commenced after which the timing can be adjusted to a limited basis according to clinician and patient considerations.¹ When the periodontal supporting tissues are normal and no occlusal settling is required, there is no evidence to support any changes in retention protocol for adult patients compared with adolescent patients. On the other hand, corrections carried out during periods of growth and eruption of teeth is considered to be less likely to relapse.⁷ According to Reitan,² there will be little or no relapse following orthodontic movement of an erupting tooth, because its supporting tissues are in a stage of proliferation as a result of the eruption process. New fibers will be formed as the root develops, and these new fibers will assist in maintaining the new tooth position.
- i. *Spacing:*** Permanent retention has been recommended following orthodontic treatment to close a midline diastema or generalized spacing in an otherwise normal occlusion.⁶⁶
- j. *Mandibular 3rd molars and mandibular anterior crowding:*** Bergstrom and Jensen's study⁶⁷ was designed to determine the extent to which third molars are responsible for secondary tooth crowding. They concluded that the presence of a third molar appeared to exert some influence on the development of the dental arch but not to the extent that

would justify either the removal of the tooth germ, or the extraction of the third molars, other than in exceptional instances. In another study, Vego (1962)⁶⁸ longitudinally examined 40 individuals with lower third molars present and 25 patients with lower third molars congenitally absent. He concluded that the erupting lower third molars can exert a force on the neighboring teeth. He also indicated, that there are multiple factors involved in the crowding of the arch. Kaplan (1974)⁶⁹ concluded that the presence of third molars does not produce a greater degree of lower anterior crowding or rotational relapse after cessation of retention. According to Kaplan, the theory that third molars exert pressure on the teeth mesial to them could not be substantiated. Ades et al (1990)⁷⁰ in their cephalometric study, found no significant differences in mandibular growth patterns between the various third molar groups whether erupted, impacted or congenitally missing, also with and without premolar extractions. They concluded that there is no basis for recommending prophylactic third molar extractions to alleviate or prevent mandibular incisor crowding. Bishara (1999)⁷¹ reviewed the various pertinent studies that studied the role of third molars in lower anterior crowding. He concluded that, the influence of the third molars on the alignment of the anterior dentition may be controversial, but there is no evidence to incriminate these teeth as being the only or even the major etiologic factor in the post-treatment changes in incisor alignment. The evidence suggests that the only relationship between these two phenomena is that they occur at approximately the same stage of development, i.e., in adolescence and early adulthood. But this is not a cause and effect relationship. If extraction is indicated, third molars should be removed in young adulthood rather than at an older age.

If one reviews all possible factors related to lower incisor irregularity it is pertinent that third molars should be included; however, as an individual entity it may not play the important role as originally proposed.

Are retention goals realistic?

Communication with a group of well-established colleagues, as indicated above and also acknowledged at the end of the paper, emphasized the fact that a successful result is when you

have a happy patient irrespective of stability or attainment of all the treatment goals. However, it was noted that ideally the quest should be no retention over the long-term, but this does not seem to be a generally attainable goal.

Stability of the end result is one of the prime objectives of orthodontic treatment. Without stability neither proper function nor the best in esthetics can be maintained.⁷² Undesirable changes in the alignment of teeth following orthodontic treatment commonly occur unless some form of retention is employed.^{15,28,73} Occlusal stability after orthodontic treatment should be considered a primary goal for every orthodontist.¹⁷ Horowitz and Hixon (1969)⁷⁴ explained physiologic recovery as the change to the original physiologic state after completing treatment. They defined relapse as “changes in tooth position after orthodontic treatment”. The proposed basis for holding the teeth in their treated position is to allow for periodontal and gingival reorganization, to minimize changes from growth, to permit neuromuscular adaptation to the corrected tooth position; and to maintain unstable tooth position, if such positioning is required for reasons of compromise or esthetics.

Comprehensive orthodontic treatment is usually carried out in the early permanent dentition, and the duration is typically between 18 and 30 months. This means that active orthodontic treatment is likely to conclude at age 14 to 15 years, while anteroposterior and particularly vertical growth often do not subside even to the adult level until several years later. Long-term studies of adults have shown that very slow growth typically continues throughout adult life, and the same pattern that led to malocclusion in the first place can contribute to deterioration in occlusal relationships many years after orthodontic treatment is completed.

It is thus clear that clinicians should strive to attain the best possible outcome following treatment and set a retention goal to assist in the long-term maintenance of the attained result. Moreover, very important is the contract or agreement with the orthodontic patient; that is, if this long-term goal is to be achieved then a mutual partnership of collaboration between clinician and patient must be established. The patient must understand the long-term changes that will occur without retention to a lesser or greater extent and that their compliance with the retention protocol mutually agreed upon is essential for ultimate success.

The count-down to appliance removal and implementation of retention

Communication amongst colleagues noted shows that good interdigitation is paramount prior to considering debonding. Treatment considerations such as sequential removal of archwires or sectioning archwires and utilizing up and down elastics will enhance interdigitation.¹ Functional relationships are reviewed and esthetic relationships such as embrasures or incisal lines are recontoured through enameloplasty.

During the last months prior to debonding and removal of appliances such variables as the Bolton relationship is finally checked, IPR performed where indicated, and less force such as intermaxillary traction applied to ensure that the attained relationships remain in the corrected positions.

Does the retainer choice matter?

Hawley retainers and vacuum- formed retainers (VFRs) are the 2 most commonly prescribed removable retainers in the United Kingdom's National Health Service (NHS). Data from the Dental Practice Board in the United Kingdom demonstrate the increasing use and popularity of VFRs.⁷⁵

Pratt et al (2011)⁷⁶ conducted an electronic survey of 36-questions that was sent to all 9143 practicing members of the American Association of Orthodontists in the United States, and 1632 (18%) responded. Mean retention protocols of the surveyed population showed predominant use of Hawley or vacuum-formed retainers in the maxillary arch and fixed retention in the mandibular arch. For both arches, there is a current shift away from Hawley retainers and toward vacuum-formed retainers and fixed retention. Respondents who extract fewer teeth reported increased use of fixed retention in the maxillary and mandibular arches. Respondents who extract fewer teeth and use removable retainers were more likely to tell their patients to wear their retainers at night for the rest of their lives.

VFRs were shown to be more effective than Hawley retainers at holding the correction of the maxillary and mandibular labial segments.⁷⁷

There is, however, no good clinical evidence to support the use of VFRs over conventional Hawley retainers. Lindauer and Shoff (1988)⁷⁸ carried out a prospective nonrandomized clinical trial to compare Essix retainers (VFR) with Hawley retainers during the first 6 months of active retention. A significant proportion (29%) of the sample was lost during the study period, so that the final sample size was small (40 total; 19 Essix, 21 Hawley) and therefore had limited statistical power. The authors found no significant differences between the 2 retainer groups when overjet, overbite, and incisor irregularity were examined over the 6-month retention period.

Evidence suggests that the Hawley might be the retainer of choice when a lateral open bite is present before debond. Sauget et al (1997) showed that the Hawley retainer allows more vertical movement (settling) of the posterior teeth than a VFR, but their sample size was small (total, 30 patients, 15 per group).^{79,80} See also the Lustig et al. paper in the present edition of this journal.

The potential cost savings in a health care system with the routine use of VFRs rather than Hawley retainers are significant. This alone justifies more research with greater statistical power to enable valid clinical and economic conclusions to be reached.⁷⁷

Fixed retainers are indicated for long-term retention of the labial segments, particularly when there is reduced periodontal support, and for retention of a midline diastema.⁵⁹ Fixed retainers are discreet and reduce the demands on patient compliance. However, they are associated with failure rates of up to 47%.⁸¹ particularly on upper incisors when there is a deep overbite. In addition, calculus and plaque deposition is greater than with removable retainers. Fixed retainers therefore require long-term maintenance. Flexible spiral wire retainers allow differential tooth movement and are particularly useful for patients with loss of periodontal support.⁸² Current orthodontic opinion recommends either the use of 0.0215 inch multi strand wire,⁸² or 0.030 - 0.032 inch sandblasted round stainless steel wire.^{83,84} There are four major fix retainer indications:⁸¹ 1) Maintenance of lower incisor position during late growth; 2) Diastema

maintenance; 3) Maintenance of pontic or implant space; 4) Keeping extraction space closed in adults.

Removable Appliances can serve effectively for retention against intra-arch instability and are also useful as retainers (in the form of modified functional appliances or part-time headgear) in patients with growth problems. These retainers are robust and can be worn during eating. Hawley retainers have been recently shown to have the advantage of facilitating posterior occlusal settling in the initial three months of retention.^{79,80} (See Lustig et al in this journal). The labial bow can be used to accomplish simple tooth movements if required, and an anterior bite plane can easily be incorporated for retention of a corrected deep overbite.⁸⁰

A recent Cochrane review examining a number of aspects of retention, including removable vs fixed retention, found the quality of the studies to be poor, and there is as yet no reliable evidence that fixed retainers are more effective than VFRs.⁸⁵ See also the Littlewood article in this edition of the journal.

A retention protocol

Comparing the position of the teeth at the conclusion of treatment with their original positions can identify the direction of potential relapse. Teeth will tend to move back in the direction from which they came, primarily because of elastic recoil of gingival fibers but also because of unbalanced tongue-lip forces. Teeth require essentially full-time retention after comprehensive orthodontic treatment for the first 3 to 4 months after a fixed orthodontic appliance is removed. To promote reorganization of the PDL, however, the teeth should be free to flex individually during mastication, as the alveolar bone bends in response to heavy occlusal loads during mastication. This requirement can be met by a removable appliance worn full-time except during meals or by a fixed retainer that is not too rigid. Because of the slow response of the gingival fibers, retention should be continued for at least 12 months if the teeth were quite irregular initially, but can be reduced to part-time after 3 to 4 months. After approximately 12 months it should be possible to discontinue retention in non-growing patients or maintain it on a limited regimen. Some patients who are not growing will require permanent retention to maintain the

teeth in what would otherwise be unstable positions because of lip, cheek, and tongue pressures that are too large for active stabilization to balance out. Patients who will continue to grow, however, usually need retention until growth has reduced to the low levels that characterize adult life.

Taken into consideration that change in the occlusal contacts will occur in the long term, the following example of a retention protocol is recommended: ¹

1. Wear the removable retainers during the first month as much as possible.
2. Fix retainers are of course permanently in place and can be maintained as long as the patient wishes. Consent is required to remove these prior to the clinicians determined protocol.
3. Drink water to adapt, but remove the retainers when eating.
4. A dental hygiene regimen should be followed without the retainers in place. Moreover, proper hygiene measures must also be in place for the retainers.
5. After the first month, the retainers only have to be worn at home and at night. This is a practical schedule as retainers are then kept at home and misplacement elsewhere will be at a minimum.
6. Retention visits are initially scheduled at 6 weeks; 3 months; 6 months; 1 year and then annually.
7. As a rule of thumb, the retainer should be in place at least for the same duration as the treatment time; however, keep in mind that depending on the age at the completion of active treatment, the physiologic changes may be rapid or at a reduced rate. Retainer wear should be determined accordingly.
8. A classic regimen also is to wear the removable retainers full time for half of the treatment time. Then divide the remainder of the treatment time in two periods; the first period is for at home wear and the second period is for night time wear; thereafter the retainers can be maintained for night-time wear or can be weaned away by alternate night

wear until it is worn only to test for a good fit. If there is any difficulty in the fit, then adjustment or at least night-time wear be maintained.

9. The ultimate goal is no retainers. The wean away process as described is thus important. Some patients prefer to maintain night-time retainer wear, and with no adverse evidence shown for this exercise, it is recommended to maintain night wear until the long-term changes have minimal effect.^{15,86}

In conclusion, one realizes that irrespective of the importance of the retention protocol it is generally recognized in the literature that there is no universal agreement regarding retention regimens and that wide variations in retention protocols exist among clinicians.⁸⁵

Acknowledgement: Appreciation is expressed to the following friends and colleagues who graciously shared their clinical experience in respect to retention questions posed by the authors.

Richard “Wick” Alexander (Arlington, Texas)

Kjell and Hege Alst (Bodø, Norway)

Aliakbar Bahreman (University of Rochester, Rochester, New York)

Jim Boley (Richardson, Texas)

Joseph Philippe BouSerhal (Beirut, Lebanon)

Donald Ferguson (European University College, Dubai, U.A.E.)

Mithran Goonewardene (University of Western Australia, Perth, Australia)

Mark Hans (Case Western University, Cleveland, Ohio)

Ashok Karad (Mumbai, India)

Simon Littlewood (London, United Kingdom)

Kari Line Roald (Larvik, Norway)

Sabine Ruf (University of Giessen, Giessen, Germany)

Gerard Steenvoorden (Soeteduinen, Netherlands)

Timothy Wheeler (Gainesville, Florida)

Larry White (Dallas, Texas)

Benedict Wilmes (Heinrich-Heine-University, Dusseldorf, Germany)

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Accepted manuscript