Enamel Reduction Procedures in Orthodontic Treatment

• **P. Emile Rossouw,** BSc, BChD, BChD (Hons), MChD (Ortho), PhD, FRCD(C) •
• **Andrew Tortorella,** BSc, DDS •

Abstract

Various combinations of enamel reduction procedures can be used to create space between teeth, to correct discrepancies between mandibular and maxillary teeth and to correct morphologic anomalies during orthodontic treatment. In particular, acid-enhanced interproximal enamel reduction significantly reduces surface roughness. This article presents a review of the literature on enamel reduction procedures.

MeSH Key Words: *dental enamel/surgery; malocclusion/surgery; orthodontics, corrective/methods*

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Dr. Charles H. Tweed, the first certified specialist in orthodontics in the United States, devoted a lifetime (1918–1970) to the advancement of the edgewise orthondontic appliance. He proposed universal goals for comprehensive orthodontic treatment: a healthy, esthetically pleasing, functional and stable occlusion, which should match an esthetically harmonious soft-tissue profile.[1] Various treatment options exist to achieve these goals. Interproximal enamel reduction, also known as interdental stripping, enamel approximation or slenderizing, is a well-known technique that is frequently applied during orthodontic treatment. Not only can the clinician achieve better alignment and occlusion of the teeth through this adjunct to overall treatment, but it also simplifies the long-term maintenance of tooth alignment. Many factors influence whether these goals can be attained, one of which is the relationship of the total mesiodistal width of the maxillary teeth to that of the mandibular teeth (the Bolton tooth-size discrepancy).[2] Orthodontic treatment should compensate for any significant variation in this relationship, and treatment planning should therefore incorporate consideration of esthetic bonding, prosthetic recontouring, stripping of enamel, extraction of teeth, allowance for spaces after tooth alignment, prosthodontic replacement of missing teeth (**Figs. 1a** and **1b**) or a change in the desired anterior overjet or overbite.[3] This literature review examines indications for and methods of enamel reduction procedures.

Indications for Enamel Reduction

The reduction of the mesiodistal dimensions of the teeth by means of interproximal enamel reduction is intended to achieve better alignment of the teeth or to maintain alignment over the long term.[4–8]

Stroud and others[9] suggested that interproximal reduction may be indicated for patients with good oral hygiene and who have either Class I arch-length discrepancies with orthognathic profiles, minor Class II dental malocclusions (particularly in patients who have stopped growing) or Bolton tooth-size discrepancies.

Space-Gaining Procedures

Space-gaining procedures have been discussed in the literature for decades.[1–3] These methods include distalization of the molars, protrusion of the incisors, expansion in width of the dental arches and extraction of teeth. Other natural means of space gaining are proper maintenance of the primate spaces (in the primary dentition) and of the leeway space or, eventually, the E space (in the mixed dentition), which is the difference in mesiodistal width between the primary second molar and the permanent second molar. Enamel reduction is an alternative method of gaining the space needed to align irregularly positioned teeth. Sheridan[10] proposed that interproximal enamel reduction with an air-rotor technique is similar to the natural process of interdental abrasion.[11] Moreover, enamel reduction has recently increased in popularity as clinicians have become more involved in the long-term maintenance of alignment of the

Figure 1a: *Patient with a Bolton tooth-size discrepancy. The patient has congenitally missing maxillary lateral incisors.*

Figure 1b: *The missing maxillary lateral incisors were replaced with a Maryland acid-etched bridge, and lower incisor interproximal enamel reduction was performed. This example illustrates a simple method of correction, which is typically applied in cases with straight soft-tissue profiles, and could provide a semipermanent replacement during growth phases or during an interim phase before placement of an implant.*

Figure 2a: *Typical use of enamel reduction in nonextraction treatment with metal strips.*

Figure 2b: *Typical use of enamel reduction in nonextraction treatment with metal disks.*

lower incisors, as well as nonextraction treatment (**Figs. 2a** and **2b**) in cases of minor to moderate crowding.[2,4,5,12–15]

In untreated normal individuals, as well as those who have undergone orthodontic treatment, the dimensions of the dental arch (arch length, arch depth and intercanine width) are continually decreasing.[16–21] This decrease in arch dimensions eventually results in a shortage of space and is expressed as crowding or tooth irregularity. It has been suggested that the clinician has a responsibility to inform patients about changes in the dentition that may occur after orthodontic treatment and to stress the importance of retention in maintaining long-term alignment (**Figs. 3a, 3b, 3c** and **3d**).[19,22,23]

Interproximal enamel reduction may be used in adult patients with crowding, where extraction of teeth is not an option.[10] The early mixed dentition often presents with incisor irregularity of 3–4 mm.[24] Preservation of the leeway space, selective disking and extraction of primary teeth to help correct a shortage of space for the permanent incisors have thus become important processes (**Fig. 4**).

Disking of the primary teeth may also be used before a decision is made to either initiate a serial extraction regimen (for selective removal of the primary and secondary teeth) or pursue nonextraction therapy.[25] Not only does mesial stripping of the primary canines provide space, but maintenance of the canines in the arch aids in the natural expansion of the permanent canines during eruption.[25] This phenomenon is particularly important in cases where the decision to extract is not clear cut.

Enamel Thickness Available for Reduction

It has been suggested that approximately 50% of the interproximal enamel can be safely removed.[5,22,23,26] Estimates of the amount of tooth structure that can be removed depend on accurate reference data for enamel thickness, which are currently unavailable. However, reduction of the interproximal surfaces of the anterior teeth has not resulted in increased susceptibility to caries or periodontal disease.[4,7,8,22,23,27,28] Although Radlanski and others[29] suggested that there was an increase in caries with interproximal reduction of the posterior segment, Crain and Sheridan[30] did not find any increase in the incidence of caries or periodontal disease 2 to 5 years after interproximal reduction. In the absence of inflammation, close root proximity after orthodontic treatment does not cause greater susceptibility to bone loss.[31] However, the smaller distance between the roots of interproximally reduced teeth may predispose patients with inflammation to more rapid progression of periodontal disease. Bitewing radiographs provide information as to the thickness of the interproximal enamel. Enamel and dentin thickness were measured by Stroud and others,[9] who reported that the enamel on the second molars was significantly thicker (by 0.3 to 0.4 mm) than enamel on the premolars. In addition, distal enamel was significantly thicker than mesial enamel. Assuming that 50% enamel reduction leaves adequate protection for the tooth, applying this procedure to the premolars and the molars should yield 9.8 mm of additional space for realignment of mandibular teeth.

Anomalies in Tooth Morphology

Many patients presenting for orthodontic treatment have a Bolton tooth-size discrepancy that may influence treatment goals and results. Freeman and others[32] found that 30.6% of orthodontic patients had a significant anterior tooth-size discrepancy, whereas Crosby and Alexander[33] reported only 22.9% in a different sample.

Figure 3a: *Removable, modified Hawley retainers are recommended to assist in long-term tooth alignment. This type of retainer contributes to a healthy periodontium and also allows for interproximal enamel reduction, which combats the effects of longitudinal arch-length reduction.*

Figure 3b: *Anterior view of removable, modified Hawley retainers.*

Figure 3c: *Mandibulor occlusal view of removable, modified Hawley retainers.*

Figure 3d: *Maxillary occlusal view of removable, modified Hawley retainers.*

Given these findings, it would seem prudent for clinicians to routinely include a tooth-size analysis in their treatment planning. Identifying such discrepancies before final tooth alignment should prove beneficial in defining the final expectations of both the clinician and the patient. Although such an analysis may be time-consuming, the benefits of interproximal stripping to correct any discrepancies would seem to outweigh the minor inconvenience of performing the analysis, which should allow more efficient diagnosis of problems, more specificity in treatment planning and a higher success rate in achieving optimal functional, stable and esthetically pleasing occlusions.

Enamel reduction also suffices for correction of a Bolton tooth-size discrepancy.[2,34] The Bolton tooth-size analysis comprises the anterior ratio (mean 77.2 ± 1.65%; range 74.5–80.4%) and the posterior ratio (mean 91.3 ± 1.9%; range 87.5–94.8%) of tooth-size differences between the mandibular and maxillary mesiodistal teeth. Interproximal enamel reduction can be used to correct the ratio and ensure well-aligned and properly occluding dentitions. In certain circumstances the ratio may even indicate the feasibility of extracting one lower incisor.

It has been shown that naturally well-aligned mandibular incisors have distinctive dimensional characteristics. Such teeth have significantly smaller mesiodistal (MD) dimension and significantly larger faciolingual (FL) dimension than mandibular incisors in the average population.[12] It appears, therefore, that tooth shape (MD and FL dimensions) may be a factor in determining whether crowding of the lower incisors will occur (**Fig. 5**).

In 1918 Ramström employed a breadth-length index in reporting the dimensions of fossilized lower molars.[12] Since then, FL and MD crown dimensions have been advantageously employed in indices to facilitate anthropologic communication.[35–43] In addition, these indices have been applied in studies of approximal and occlusal tooth wear.[44,45]

Peck and Peck[12] used this information to develop their index for use in clinical orthodontics. The index uses an MD/FL ratio, which determines whether a lower incisor is favourably or unfavourably shaped to achieve good lower anterior alignment.[12] The following ranges are employed as clinical guidelines for the maximum desirable MD/FL index values for the lower incisors: 88% to 92% for the mandibular central incisor and 90% to 95% for the mandibular lateral incisor. Enamel reduction assists in adjusting values to within these ranges.

Cosmetic Recontouring

Extensive remodelling of teeth by enamel grinding is sometimes necessary in orthodontic treatment to attain the desired esthetic objectives (**Figs. 6a** and **6b**).[46–48] In one study, canines were ground to the shape of the lateral incisors as part of orthodontic treatment, and subsequent recall clinical examinations after 10 to 15 years indicated favourable long-term results.[49] No significant colour differences were observed, nor were there any significant differences between ground and unground teeth with regard to mobility, reaction to percussion or temperature sensitivity. Electric pulp testing also revealed no statistically significant differences between test and control teeth. Marked radiographic changes (pulp obliteration) were evident in 2 of the 37 ground canines. Scratches were observed with stereomicroscope investigation on only 2 of the ground labial surfaces. Thordarson and others[49] reported that these scratches and grooves were originally produced by the diamond recontouring instrument and were still evident more than 10 years after the procedure. In all other instances the ground surfaces were indistinguishable from normal adult enamel surfaces. The authors concluded that

Figure 4: *Reduction of the mesial enamel of the primary cuspid to assist in alignment of the permanent incisors.*

Figure 5: *Successful long-term maintenance of lower incisor alignment. The patient received nonextraction treatment, including minor interproximal enamel reduction, with fixed orthodontic appliances to create space for incisor alignment. The active orthodontic treatment was followed by placement of a removable, modified Hawley retainer.*

Figure 6a: *Orthodontic appliances were used to close the lateral incisor spaces. The canines were positioned to replace the congenitally missing maxillary lateral incisors. The mandibular second premolars were extracted to correct the mandibular crowding and to establish a functional anteroposterior occlusion.*

Figure 6b: *Cosmetic reshaping of the maxillary canines and esthetic bonding were completed. This method is usually followed by lower interproximal enamel reduction to ensure appropriate Bolton tooth-size harmony.*

extensive cuspal, labial, lingual and interproximal recontouring accomplished by the grinding of young teeth in association with orthodontic treatment can be performed without discomfort to the patient and with only minor or no long-term clinical or radiographic reactions.

Methodological Advantages and Disadvantages

Despite its advantages, enamel reduction also presents some disadvantages. In operative dentistry it is of the utmost importance to avoid touching a neighbouring tooth during preparation of an approximal cavity, although in orthodontic treatment the interdental tooth enamel is ground down therapeutically. The potentially iatrogenic effects of interproximal reduction include increased frequency of caries, periodontal disease and temperature sensitivity.[50–52]

Air-rotor stripping may increase the susceptibility of proximal enamel surfaces to demineralization relative to that of nontreated surfaces.[53] However, ideal alignment by enamel reduction was reported to improve interproximal gingival health.[4] Enamel reduction could also lead to greater plaque retention (relative to untreated enamel) because of residual furrows left on the enamel surface by the scouring effect of the stripping procedure.[54]

Crain and Sheridan[30] did not find a statistically significant relationship between interdental enamel reduction (performed 2 to 5 years earlier) and caries susceptibility or periodontal disease. Similarly, el-Mangoury and others[55] performed scanning electron microscopy (SEM) and concluded that interproximal enamel reduction in the posterior segments did not expose the teeth to pathologic caries and that spontaneous remineralization of the hard tissue followed after a demineralization period of approximately 9 months. A mechanical stripping procedure combined with the chemical action of 37% phosphoric acid produced enamel surfaces that encouraged "self-healing" on the basis of remineralization enhanced by the application of fluoridating or remineralizing solutions.[54] Leclerc[56] carried out a complete analysis, using SEM to investigate existing stripping procedures. The author proposed using a diamond disk, followed by a diamond bur, 16- and 30-blade tungsten carbide burs and a polishing paste.

Various other techniques have been described to reduce the mesiodistal dimension of teeth, including use of special hand instruments and motorized handpieces such as the Profin Directional System (Dentalus, New York).[57,58] Piacentini and Sfondrini[59] tested healthy human teeth obtained after extraction for orthodontic or periodontal reasons. The teeth underwent enamel stripping according to various techniques, including mechanical stripping with burs and chemical stripping with phosphoric acid. SEM demonstrated that, with normal polishing and cleaning methods, it is impossible to eliminate the furrows left on the enamel by diamond burs and disks and 16-blade tungsten carbide burs. In addition, mechanical and chemical reduction techniques were ineffective when performed according to accepted methods. In contrast, Piacentini and Sfondrini[59] showed that well-polished enamel surfaces can be obtained by using a tungsten carbide bur with 8 straight blades, followed by Sof-Lex disks (3M, St. Paul, Minnesota) These authors noted that the enamel surfaces were smoother than intact or untreated enamel.

Polishing enamel after reduction to make it appear similar to normal tissue before treatment is extremely difficult.

In addition, the abraded areas may favour the adherence of bacterial plaque and may offer little resistance to breakdown.[61] Joseph and others[54] proposed a combined mechanical and chemical technique in an effort to create a smooth enamel surface. However, Piacentini and Sfondrini[59] reported that use of phosphoric acid yielded only an etched adamantine surface, which they maintained was susceptible to decalcification, despite the application of calcifying or fluoridating solutions, as suggested by Joseph and others.[54] Piacentini and Sfondrini[59] believed that such a method could be risky because of rapid plaque accumulation on the enamel surface, which might result in greater exposure to carious agents. They showed that satisfactory results could be achieved with their technique, whereby a tungsten carbide bur is used as the first bur and polishing is accomplished with a series of fine Sof-Lex disks.[59]

Conclusions

Interproximal enamel reduction has been suggested as a preventive[61,62] and therapeutic[63] measure. It is a valuable clinical technique that increases the orthodontic armamentarium. To eliminate the disadvantages that have been described, testing and development of various techniques are imperative to ensure that the procedure yields a smooth enamel surface. ◆

Dr. Rossouw *is professor and clinic director, Baylor College of Dentistry, Dallas, Texas.*

Dr. Tortorella *maintains a private practice in Niagara Falls, Ontario.*

Correspondence to: *Dr. P. Emile Rossouw, Professor and Clinic Director, Baylor College of Dentistry, 3302 Gaston Ave., Dallas, Texas 75246, USA. E-mail: ERossouw@tambcd.edu.*

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