

Interproximal enamel reduction as a part of orthodontic treatment

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SUMMARY

Objective. Interproximal enamel reduction is a part of orthodontic treatment for gaining a modest amount of space in the treatment of crowding. Today interproximal enamel reduction has become a viable alternative to the extraction of permanent teeth, and helps to adjust the Bolton Index discrepancy. The aim of the study is to evaluate various interproximal enamel reduction techniques, its indications, contraindications and complications presented in recent scientific studies.

Material and methods. Papers published in English language between 2003 and 2012 were searched in PubMed, ScienceDirect and The Cochrane Library databases, as well as the Web search Google Scholar. Initial searches were made to find peer-reviewed systematic reviews, meta-analyses, literature reviews, clinical trials, which analysed at least one interproximal enamel reduction method. 31 published data fulfilled the inclusion criteria.

Results. According to the study, abrasive metal strips, diamond-coated stripping disks, and air-rotor stripping are the main interproximal enamel reduction techniques. Indications for use are mild or moderate crowding in dental arches, Bolton Index discrepancy, changes in tooth shape and dental esthetics within the enamel, enhancement of retention and stability after orthodontic treatment, normalization of gingival contour, elimination of black gingival triangles, and correction of the Curve of Spee. Complications of interproximal enamel reduction are hypersensitivity, irreversible damage of dental pulp, increased formation of plaque, the risk of caries in the stripped enamel areas and periodontal diseases.

Conclusion. Interproximal enamel reduction is an important part of orthodontic treatment for gaining space in the dental arch, and for the correction of the Bolton index discrepancy.

Key words: interdental stripping, interproximal enamel reduction, mesiodistal reduction, reproximation, air-rotor stripping.

INTRODUCTION

The main goals of orthodontic treatment are to create the best balance among occlusal relationships, dental and facial esthetics, and long-term treatment stability. Reaching these ideals is difficult in many patients because the excess tooth structures often interfere with the correct alignment of the teeth in the dental arch. Dental crowding is one of the most common findings in orthodontic patients. Many cases of dental crowding show a higher

prevalence for the anterior region. There are several methods of relieving dental crowding - transverse arch expansion, proclination of the anterior teeth, distalization of the teeth in the arch, extraction of the tooth, or interproximal enamel reduction. The amount of crowding, facial profile, and patients' age determine the choice of the treatment strategy. Since 1944, when Ballard first used interproximal enamel reduction for the anterior segment (1), there have been many different techniques created for gaining space in the dental arch: Hudson (1956), Paskow (1971), Peck and Peck (1972), Sheridan air-rotor stripping (ARS) (1985), and Zachrisson's method (1986). Interproximal enamel reduction (IER) is a clinical procedure involving the reduction, anatomic re-contouring, and protection of interproximal enamel surfaces of permanent teeth. For patients with mild or moderate crowding (4-8 mm), this is

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an alternative to dental extraction. However, it is irreversible (2), and therefore careful examination before the procedure is mandatory. IER cannot be considered as an independent treatment, but rather only as a part of orthodontic treatment (3-5). The aim of the study is to evaluate various interproximal enamel reduction techniques, its indications, contraindications and complications presented in recent scientific studies.

MATERIAL AND METHODS

A systematic literature review was carried out to identify, appraise, select and synthesize all high quality relevant studies reporting data on interproximal enamel reduction. Initial searches were carried out on these databases: PubMed, ScienceDirect and The Cochrane Library, as well as the Web search Google Scholar, to find systematic reviews, meta-analyses, literature reviews, randomized controlled trials and clinical trials. The following MeSH terms or/and word combinations were used: “interdental stripping”, “interproximal enamel reduction”, “mesiodistal reduction”, “reproximation”, and “air-rotor stripping”. It was found 3630 articles during the initial searches. Irrelevant articles were discarded on the basis of the title, abstract and the original language (only English language was acceptable). Articles were included in the study if they complied with the following inclusion criteria:

- Papers published between 2003 and 2012. IER articles were searched up to 10 years old, because it was insufficient data following the 5 year old criteria.
- Peer-reviewed systematic reviews, meta-analyses, literature reviews, clinical trials, which analysed at least one IER method.
- Clinical trials including more than 40 patients (or extracted teeth).
 - Human subjects.
 - Extracted teeth.

Exclusion criteria. From the titles and abstracts derived from searches, studies were excluded if they were non peer-reviewed publications, case reports or clinical trials including less than 40 patients (or extracted teeth), but we read them to identify any potential studies.

Full texts of the selected articles were independently analyzed by two authors. In reading the articles, we checked the reference lists to identify any other articles that may have been relevant to the research question. After removing duplicates and non-english articles, 31 published data fulfilled the inclusion criteria.

RESULTS

IER is a common clinical procedure in orthodontic therapy for gaining a modest amount of space and has become a viable alternative to the extraction of permanent teeth in the treatment of crowding.

Indications for interproximal enamel reduction

The main indications for IER in the treatment of adults are crowding (1, 4-13), when the lack of space in the dental arch is 4 to 8 mm (2, 6, 8, 14), Bolton Index discrepancy (2, 4-9, 12, 14-16), changes in tooth shape and dental esthetics within the enamel (17), the ability to safely obtain sufficient space for tooth movement without the need for extractions (2, 6, 9, 10, 16, 18, 19), macrodontia (4, 6), enhancement of retention and stability after orthodontic treatment (5, 6, 8-10, 12, 16, 17), normalization of gingival contour and elimination of black gingival triangles (2, 4-6, 10, 15, 20, 21), and correction of the Curve of Spee (6, 8). IER should be carried out only in patients with a low risk for caries and good oral hygiene (2, 6, 10) to avoid increased susceptibility to caries. After creating proper interdental contacts, the risk of tooth mobility or loss of alveolar bone or root cement is decreased. Lastly, one of the advantages of IER is short performance time (2).

The most recent methods of interproximal enamel reduction

Before performing IER it is important to evaluate how much of enamel can be reduced. This can be made by projecting a line from the cervical line vertically to the occlusal plane because dentin is projected in a straight line from the cervical line (6). Hudson, Gillings and Buonocore, and Shillingburg and Grace in Fillion in their studies showed that enamel thickness is less than 1 mm, although starting with the distal surface of the canine, the thickness is greater (2). Also, these studies revealed that the enamel is slightly thinner in the distal than in the mesial surfaces, and there is no relationship between dental shape and enamel thickness (19). Another way of measuring enamel thickness is using special gauges, up to the accuracy of one-tenth of a millimeter (14). Only knowing the thickness of the interdental enamel, an orthodontist can decide how much of it can be removed. Fillion recommends never to remove more than 0.3 mm of the enamel from the upper incisors, 0.6 mm – from the upper posterior teeth, 0.2 mm – from the lower incisors, and 0.6 mm – from the mesial surface of the lower posterior teeth (2). Chudasama and Sheridan claim

that interdental enamel is thinner on the upper lateral incisors and lower incisors, and therefore only 0.5 mm should be removed from these contact points (14). Sheridan and Ledoux claim that 6.4 mm of space can be gained by interproximal enamel reduction of eight proximal surfaces of the premolars and molars (22). Stroud *et al.* considered that it is possible to achieve 9.8 mm by applying the same procedure.

First of all, before the IER procedure, rotated teeth must be fully aligned (2, 3, 23). It is after leveling and aligning the teeth or in the finishing stage that it becomes clear whether correct occlusion can be achieved or not (2). After the alignment, separators or a single-sided diamond-coated disk should be used to make space between the teeth, which improves visibility and access to the contact point (24). Not all the teeth should be stripped during a single appointment (2). IER is performed with water or air cooling. During the IER, the anatomy of the teeth is changed, and thus it is very important to place the contact point between the teeth in the correct anatomical location, and to restore tooth contours to the original form to the greatest possible extent. After the IER, the enamel must be polished using finishing disks or strips (1, 2, 4, 6, 14, 20, 22, 23, 25, 26), and a fluoride solution should be prescribed (27). Research indicates that fluoride

increases remineralization of the abraded enamel surfaces (2, 4-6, 9, 10, 14, 23, 28).

When choosing materials for IER, it is important to decide what instruments and soft tissue guards are going to be used. IER materials are divided into manual and rotary instruments (2). Each of them has advantages and disadvantages (Table 1).

Currently, there are 3 most common IER techniques (1, 4, 5, 9, 25):

1. The air-rotor stripping technique with fine tungsten-carbide or diamond burs and diamond-coated strips;
2. Hand-piece or contra-angle-mounted diamond-coated disks;
3. Handheld or motor-driven abrasive metal strips.

The technique of IER depends on the severity of crowding and the segments of the teeth. A metal abrasive strip is a manual instrument for anterior teeth enamel reduction. The strip can be used in an operator's hand, the Mathew hemostat, or in special strip holder (7, 8). Diamond disks are abrasive diamond-coated disks available in varying thicknesses and grits, similar to strips. They can be single- or double-sided, and can be used in a hand-piece or in accordance with the method proposed by Tuverson (2) (Figure 1). The third most popular IER technique is air-rotor stripping (ARS). ARS was first

Table 1. Comparison of interproximal stripping techniques

Instruments used for IER	Manual/Rotary instruments	Advantages	Disadvantages
Thin metal strip with an abrasive material	Manual	Can be used when the teeth are so rotated that a disk is not appropriate. Can be used for re-contouring teeth after IER.	Impractical, unproductive, and time-consuming when used for buccal teeth. Leaves bits of the strip lodged between the teeth.
Diamond discs	Rotary instrument	The smoothest enamel surface is achieved when using with polishing after IER.	Dangerous using on a high speed rotating instrument in close proximity to a patient's tongue, cheeks and lips. Using a disc guard to the hand piece to guard against the possibility of cutting into soft tissues reduces visibility. Unpredictable results. Leaves deep cuts on the enamel.
Burs	Rotary instrument	Have deactivated points that will not create ridges in the proximal enamel. Painless and precise.	Leave the roughest enamel surface after IER compared to diamond discs and metal strips. Diamond and carbide burs do not provide enough flexibility.
Ortho strip system	Manual	No risk of cutting into the soft tissue. Enamel surface is smoother than after ARS. Predictable results. One side coated only to protect the adjacent tooth.	Longer procedure time compared to ARS.



Fig. 1. Separator and air cooling during interproximal enamel reduction with the modified Tuverson technique, using a diamond disk in 4-handed approach [5].

described more than 20 years ago by Sheridan as an alternative to extraction or expansion in borderline cases (14, 28). It generates space primarily in buccal segments. Using the ARS technique, one can easily create as much space as needed, and thus there is no need to close the gaps between the teeth - which always appear after tooth extraction. The application of extraction or expansion is difficult when treating patients who more and more often choose clear plastic appliances such as Invisalign. An alternative to the treatment of mild-to-moderate crowding is ARS (23, 29). When applying ARS, the recommendation is to use burs with safety-tipped non-cutting areas to prevent furrows of the proximal walls, which can occur when using conventional burs with squared-off tips (2) (Figure 2). "Intensive Ortho-Strips" is one more method of IER, which is currently gaining in popularity. It is used as an alternative to ARS. Ortho-strips are thin, semi-flexible strips used in a special holder (Figure 3). Intensive Proxo shapes are flexible thinner blades that can remove very small amounts of the intermolar enamel to provide banding space if separation has not been effective (14). This technology takes more time than ARS, but the results are more predictable, and the enamel surface will be smoother than that achieved when using burs

Table 2. Complications of interproximal stripping *in vivo*

Authors of the article	Number of patients	Complications
Zachrisson BU, Minster L, Ogaard B, Birkhed D (2011) [4]	43	2.5% of new caries lesions (all grade 1) were found during clinical and radiographic assessments of 278 mesial or distal surfaces following enamel reduction. These lesions were found in 3 of 43 patients.
Kanoupakis PM, Peneva MD, Moutaftchiev VY (2011) [10]	53 patients studied after 18-24 months following IER	4.7% of stripped surfaces registered via DIAGOdent showed initial enamel change after interproximal enamel reduction.
Zachrisson BU, Nyoygaard L, Mobarak K (2007) [5]	61	One patient had generally sensitive teeth, and 1 complained of increased sensitivity of the mandibular incisors.
Jarjoura K, Gagnon G, Nieberg L (2006) [28]	40 patients studied after 1-6 years following IER	3 of 376 surfaces after IER had new interproximal lesions.

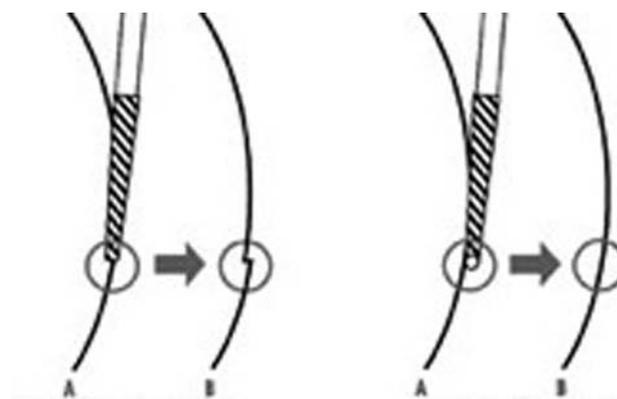


Fig. 2. Bur with a "deactivated" point [2]

(22). To protect the interdental tissues during IER, a rubber dam (6), a disk guard, an indicator wire (14), or wooden wedges should be used (2).

Contraindications for interproximal enamel reduction

Contraindications for IER are the following: crowding more than 8 mm per arch (4, 6), poor oral hygiene, active periodontal diseases (4, 6), enamel hypoplasia (19), hypersensitivity to cold (4, 6), high caries index, and multiple restorations – because there is a risk of causing imbalance in an unstable oral situation (the treatment outcomes and possible complications are difficult to predict) (6-8); rectangular-shaped front teeth (4, 6, 19) – because it is difficult to create appropriate contact points (7); round-shaped premolars (4); and young patients with large pulp chambers (7, 8, 19). If the technique is utilized correctly, there is no evidence that it can be harmful to the hard tissues or soft tissues of the teeth (4, 6).

Complications of interproximal enamel reduction

Excessive IER can lead to hypersensitivity (7, 8), irreversible damage of the dental pulp (10, 11),



Fig. 3. “Ortho-strip” with a special holder

increased formation of plaque (4, 5, 7, 15, 22), caries (7, 8, 15), and the risk of periodontal diseases in the stripped enamel areas (Table 2).

Hypersensitivity to temperature changes depends on the age of the patient (6-8), the severity of crowding (6, 8, 15), pathological tooth wear (8), hypersensitivity before treatment (6), and the amount of the removed enamel (14, 15, 23). Iatrogenic injuries to the proximal enamel surface can be predisposing factors for periodontal diseases and caries (30) because interdental enamel becomes more sensitive to demineralization. The risk of irreversible pulp damage is the highest when a tungsten carbide bur is used for IER for the lower incisors (30). Trauma to the pulp and dentin results from the revolutions per minute, bur design, and the type of coolant used during IER (30). Air or water spray are the most effective cooling techniques. They limit temperature elevation in the pulp chamber (30). After IER, many more furrows are left on the interdental enamel - even after polishing (25), and therefore plaque accumulation is more intensive (2). After IER, patients have to follow a good oral hygiene regimen, and to undergo regular prophylactic checkups for caries. The lowest amount of plaque and the smoothest enamel surface were achieved

when the enamel was stripped by a diamond-coated disk followed by polishing with the Sof-lex (3M ESPE), while the roughest enamel surface was observed after chemical stripping and ARS without polishing (1, 31). After IER, there was a minimal detection of new carious lesions in the interdental enamel (4, 5, 10, 15, 28). Studies have shown that hard and soft tissues of the teeth can adapt to changes made during the IER procedure without unfavorable consequences; moreover, the stripped enamel surface is more resistant to caries than intact enamel is (14, 23). Crain and Sheridan (15), and Zachrisson, Nyoygaard and Mobarak (5) deny the risk of periodontal diseases after IER. Frindel (2) claims that periodontal diseases might be caused by damage to the cemento-enamel junction during IER in a non-triangular-shaped tooth. Moreover, Fillion concluded that “the removal of interproximal enamel has no negative effect on the periodontium and it might, in fact, have the beneficial effect, under certain conditions, of improving the resistance of bone to disease” (2).

CONCLUSIONS

1. Interproximal enamel reduction is a part of orthodontic treatment for gaining a modest amount of space and adjusting the Bolton Index discrepancy, and is a viable alternative to the extraction of permanent teeth. The main interproximal enamel reduction techniques are abrasive metal strips, diamond-coated disks, and air-rotor stripping.

2. Indications for interproximal enamel reduction are mild or moderate crowding in dental arches, the Bolton Index discrepancy, changes in tooth shape and dental esthetics within the enamel, enhancement of retention and stability after orthodontic treatment, normalization of gingival contour, elimination of black gingival triangles, and correction of the Curve of Spee.

3. Possible complications of interproximal enamel reduction are hypersensitivity, irreversible damage to the dental pulp, increased formation of plaque, the risk of caries in the stripped enamel areas and periodontal diseases.

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