

Inter-proximal enamel reduction in contemporary orthodontics

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In brief

Details the relative indications for a common space-gaining procedure increasingly used during adult orthodontics.

Highlights the pitfalls of inter-proximal reduction allied to diagnostic considerations and technical approaches promoting successful outcomes.

Presents and appraises a plethora of available armamentarium to carry out safe and precise inter-proximal reduction.

Inter-proximal enamel reduction has gained increasing prominence in recent years being advocated to provide space for orthodontic alignment, to refine contact points and to potentially improve long-term stability. An array of techniques and products are available ranging from hand-held abrasive strips to handpiece mounted burs and discs. The indications for inter-proximal enamel reduction and the importance of formal space analysis, together with the various techniques and armamentarium which may be used to perform it safely in both the labial and buccal segments are outlined.

Introduction

Inter-proximal reduction (IPR), reproximation, slenderisation or air-rotor stripping is an adjunctive orthodontic treatment procedure that may be used in both the labial and buccal segments to gain space.^{1,2} In view of the current emphasis on non-extraction based orthodontics, alternative space-gaining procedures including arch expansion, non-compliance molar distalisation,³ such as the use of fixed mini implant-supported adjuncts, and preservation of the leeway space are increasingly being explored.⁴ Furthermore, IPR has gained increasing popularity due to the growing acceptance of adult orthodontics coupled with the difficulty associated with space closure in older patients, reticence of some patients to undergo extractions, the ability to create a more precise and appropriate amount of space in selected cases, and the risk of reopening of extraction spaces following appliance removal.

Inter-proximal reduction is typically indicated in the resolution of mild to moderate crowding (up to 8 mm),⁵ the correction of Bolton tooth size discrepancies,⁶ and in the enhancement of dental aesthetics. There is also limited evidence alluding to the potential for improved long-term stability with contact point reshaping.⁷⁻⁹ IPR may be exploited in conjunction with fixed appliance therapy, although its application with removable appliance therapy such as proprietary clear aligners including Invisalign is commonplace.

The concept of IPR is based on the findings of Begg¹⁰ who studied aboriginal groups and noted an absence of dental crowding in combination with natural occlusal and interproximal wear attributed to non-refined abrasive diets. Subsequently, IPR was popularised by Sheridan^{1,11} who described its potential remit as an alternative to extraction or expansion in selected cases. This paper aims to outline considerations underpinning safe and effective IPR as well as highlighting the various techniques and armamentarium available.

IPR is typically undertaken in adult patients rather than adolescents as the contact points tend to be more accessible and adequate gingival retraction and visualisation of contacts is more difficult in adolescents. Moreover, poorly performed IPR can produce irreversible enamel furrows, scratches and ledges, predisposing to plaque retention. There is also a risk of sensitivity if the underlying dentine is exposed. The production of a smooth enamel surface and sparing excessive removal of enamel are therefore imperatives. Long-term evidence, however, suggests that IPR is safe with no increased risk of caries or periodontal disease ten years subsequent to IPR with diamond disks.¹² Similar findings have been reported following air-rotor stripping in the buccal segments up to six years later.^{13,14}

Considerations during planning

A thorough space analysis should be carried out to calculate the exact amount of space required. A decision as to whether sufficient space may be generated with IPR in order to achieve treatment objectives is essential. Moreover, IPR does carry demonstrable albeit limited associated risk. As such it should only be planned when necessary. Accepted formal approaches to space planning are recommended in order to select the appropriate mode of space creation.¹⁵⁻¹⁷

General principles

While the use of inter-proximal reduction has become more widespread, clearly acceptable oral hygiene, absence of dental disease, and lack of previous proximal reduction are prerequisites.

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Enamel thickness

Before deciding how much enamel can be safely removed, an appreciation of the volume of available enamel is important. In general, enamel is slightly thicker in the region of the contact point and gradually decreases towards the cemento-enamel junction. It appears that the amount of enamel is unaffected by gender¹⁸ although there is some racial variation.¹⁹

In the lower labial segment, enamel is slightly thicker on the distal surfaces, with thicker enamel on both surfaces of the lateral incisors (Table 1).¹⁹ Similarly, in the anterior region the enamel is slightly thicker on the distal surfaces of both the lateral and central incisors, with a mean difference of 0.1 mm.²⁰ In the lower buccal segments, enamel is also significantly thicker on the distal surfaces, with the second molars having thicker enamel than the premolars by the order of 0.3–0.4 mm.¹⁸

It has been widely suggested that up to 50% of proximal enamel can be removed by IPR without any deleterious effects.^{1,12,21} Tuverson²² recommends removal of 0.3 mm on each lower incisor proximal surface and 0.4 mm on the canine proximal surfaces. However, Sheridan²³ suggests 0.25 mm reduction of enamel in the anterior region and a more radical 0.8 mm on each proximal surface of the posterior teeth resulting in a potential space gain of almost 9 mm. The magnitude of possible IPR is also affected by the amount of pre-existing interproximal wear. Although standardised radiographs may be useful in quantifying the

Table 1 Incisor width and enamel thickness for all subjects¹⁶

Mandibular incisor	Mean tooth width (MM) ± SD*	Mean enamel thickness on mesial surface (MM) ± SD	Mean enamel thickness on distal surface (MM) ± SD
Right central	5.45 ± 0.36	0.72 ± 0.10	0.77 ± 0.11
Left central	5.45 ± 0.36	0.71 ± 0.10	0.77 ± 0.11
Right lateral	5.96 ± 0.42	0.79 ± 0.11	0.95 ± 0.13
Left lateral	5.98 ± 0.43	0.81 ± 0.11	0.96 ± 0.14

*SD: Standard deviation

amount of enamel present, these should be used with caution as they risk overestimating the amount of enamel present.²⁴

Contact point location

In general, contact points are rounded and are more occlusal in the anterior region and become more apical posteriorly. The process of enamel reduction flattens the contact area leading to apical movement of the contact point. It is suggested that the interproximal contact remains 4.5 to 5 mm from the upper border of the alveolar crest to ensure that 'black triangles' are not visible.²⁵ In a healthy periodontium, the alveolar crest is 1.5–2 mm apical to the cemento-enamel junction. It is important to restore the normal anatomy of the contact point and area following reduction. An apical contact point may be physically difficult to reduce; apical relocation of the contact point may also impinge on the biological width of the periodontium.

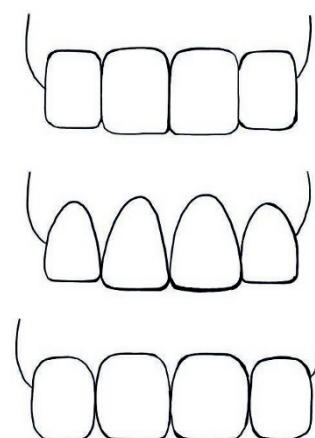


Fig. 1 Illustration of variations in crown morphology. Teeth of triangular morphology are best suited to IPR, while rectangular teeth risk creation of ledges and imperfect inter-proximal contacts



Fig. 2 (a–f) Triangular shaped teeth with unaesthetic gingival contour. Alignment without IPR would result in increased show of black triangles due to their morphology. Tooth shape should be evaluated at the diagnostic stage and the need for IPR to address black triangles as well as to produce more stable contact points should be planned and communicated at the outset

Mesio-distal tip

Ideally, mesio-distal tip should be corrected before carrying out IPR in order to allow even enamel reduction across the contact point. In addition, reduction should be carried out perpendicular to the interdental papillae to avoid introducing a tipped appearance to the teeth.

Shape and size of teeth

Bennett²⁶ described three main incisor crown shapes (Fig. 1) – rectangular, triangular and barrel shaped, although there is not necessarily a correlation between tooth shape and enamel thickness. Rectangular teeth have broad contact points with no visible spaces. Triangular teeth commonly have incisal

contact points with visible ‘black triangles’ (Fig. 2). Due to the shape of these teeth, even minimal enamel reduction can generate significant space within the arch. Barrel shaped teeth tend to have contact points in the middle of the tooth with apparent space at the incisal edges. Enamel reduction may approximate the incisal edges, but may relocate the contact point apically. The size of teeth must also be considered as microdont teeth, for example, peg laterals, may not be amenable to IPR whereas anatomically larger teeth may have more favourable morphology (Fig. 3).

Rotations

The presence of rotations may preclude adequate access to reduce the interproximal

enamel evenly. Therefore, enamel reduction may need to be carried out in stages as it may be necessary to align the teeth first. If the contact point of a tooth is completely excluded then it can be reduced prior to alignment depending on its accessibility.

Restorations

The presence of restorations poses a number of considerations for IPR. In particular, the contact point anatomy may have been altered when the restoration was placed and thus may need replacement following reduction. However, the presence of large interproximal restorations may facilitate larger increments of IPR and therefore more space gain.



Fig. 3 (a-j) Due to their increased mesio-distal width, the maxillary lateral incisors in this case were selected for IPR as a means of gaining space to alleviate crowding. Pre-treatment space analysis revealed a significant upper arch space deficit necessitating space recreation to produce ideal alignment while limiting any increase in overjet

Mode	Instruments	Cost	Manufacturer	
Manual	Hand strips	£1.15–9.10	Ortho Technology, Ortho Care, Dentsply	
	(Fig. 5a)	Handle: £35.95		
Mechanical	Rotary	Diamond discs	£15.10–31.75	Ortho Technology, Ortho Care, Dentsply
		(Fig. 5b)	Safety guard (metal): £27.60–48.25	
	Oscillating	Handpiece mounted strips	£5.92–18.89	Intensiv, Dentsply
		(Fig. 5c)		
	Segment disc	£35.95	Komet	
	(Fig. 5d)			
Burs	Safe Tipped Air-Rotor Stripping (STARS) Burs	£7.95–11.35	Ortho Care, Dentsply	
	(Fig. 5e)			

Based on online prices 06/16

Procedure

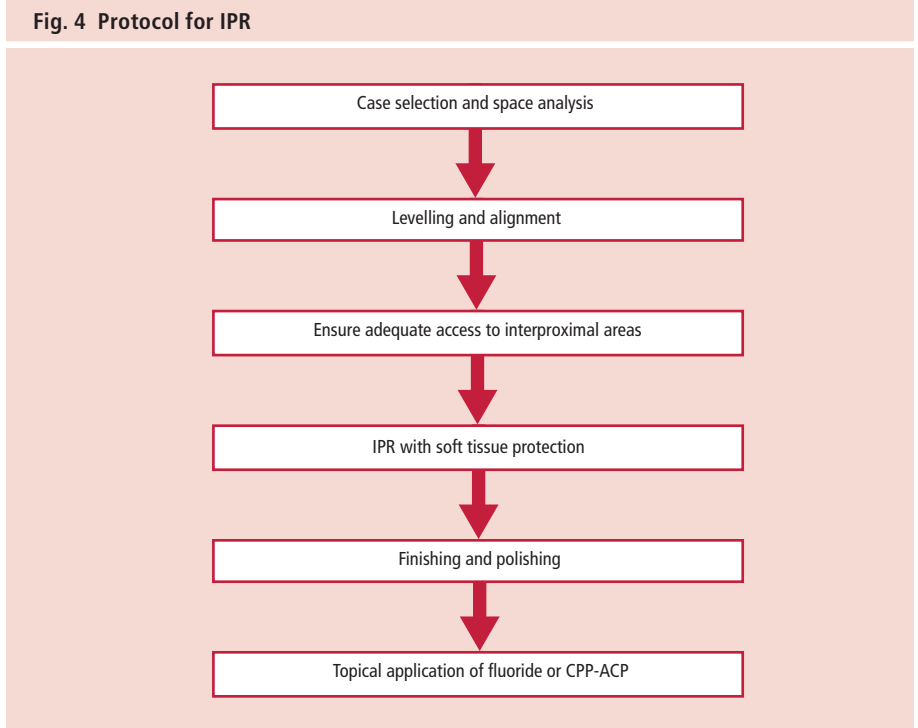
A step-by-step protocol for IPR is illustrated in Figure 4. The merits of placement of supplemental fluoride or casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) following IPR is debatable as spontaneous remineralisation has been shown to occur after nine months on untreated surfaces.²⁷

Armamentarium

Numerous materials are available to perform IPR. These approaches encompass two main categories: manual or mechanical. When deciding on the preferred armamentarium, patient safety is paramount in ensuring adequate protection of the soft tissues and prevention of overheating of tooth tissue. Some of the more recognised commercially available IPR armamentarium are outlined in Table 2. Each has unique advantages, disadvantages and relative indications.

Inter-proximal strips

Hand-held abrasive strips are manufactured in different sizes and varying grit. They allow easy access to the interproximal area and can also be used for finishing or recontouring of proximal surfaces. The strips can be hand-held or mounted on a handle. Access can be challenging in the posterior region, they are time-consuming to use, and can lead to discomfort. They can be useful in removing enamel very sparingly with increasing grades permitting progressive increase in the magnitude



of enamel removal. The strips are available colour-coded with varying widths and grits. They can be single or double-sided to allow selection of specific surfaces for reduction.

Rotary discs

Rotary diamond discs can effectively facilitate IPR and may be less time-consuming to use compared to hand strips. As is the case with hand strips, they are available in various thicknesses and grits. They require mounting on a handpiece and should be used with a safety guard to protect the soft tissues. Anterior

segment contact points are more accessible compared to posterior segments where access to allow use of discs can be technically more difficult.

Oscillating strips

Oscillating strips or discs are quick to use and allow for precise enamel reduction (Fig. 6). The segmented disc systems promote enhanced visualisation and access when compared to 360 degree rotary discs. They are also handpiece-mounted, are available in various widths and are colour-coded. They can be

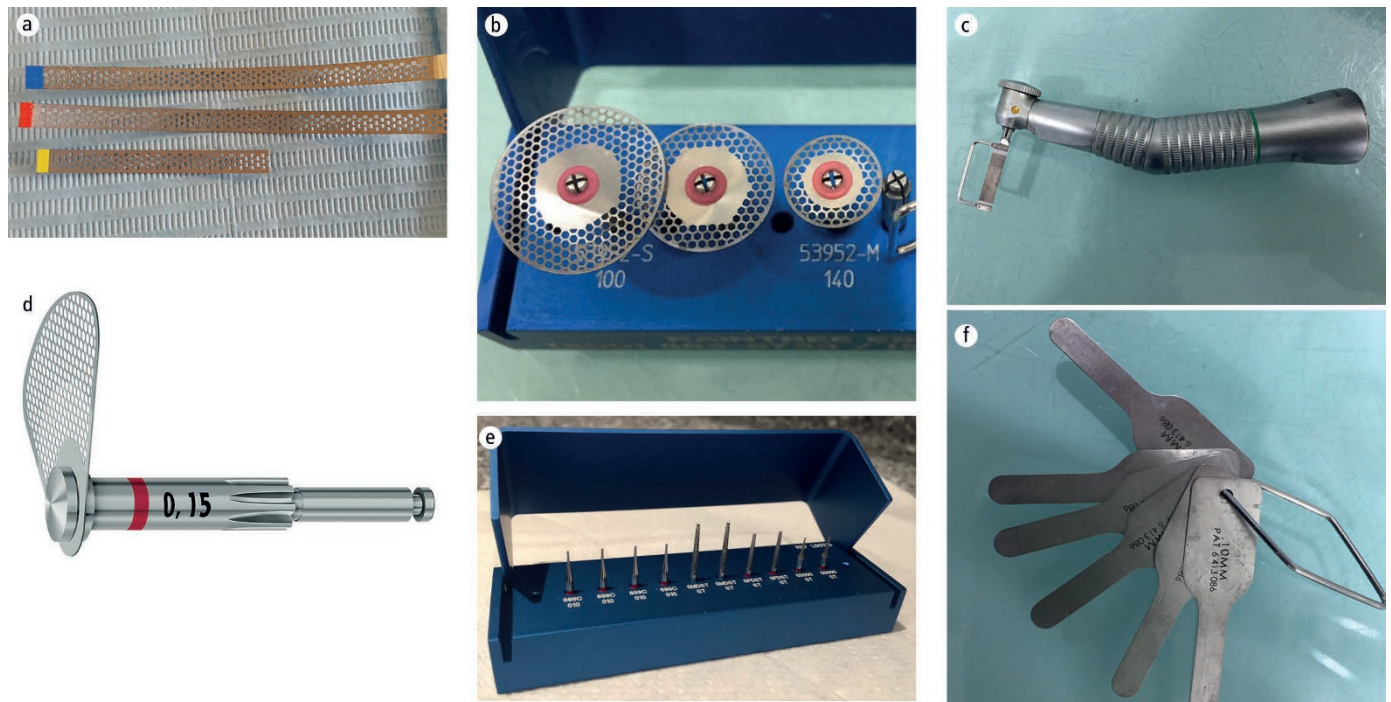


Fig. 5 (a-f) Armamentarium for IPR

single or double-sided, offering control of specific contact point reduction. IPR using this technique should be carried out incrementally, progressing through increasing widths to the desired amount rather than selecting the thickest width first. This modality is particularly useful in the anterior segments due to ease of access. Care must be taken to avoid excessive pressure, as this will risk fracture of the strip and ledging of the enamel surface.

Burs

Chudasama and Sheridan⁵ advocate the use of safe-tipped air-rotor stripping (STARS) burs which have non-cutting areas designed to prevent notching of proximal walls whilst removing a precise amount of enamel. It does, however, require subsequent finishing with fine rotary discs or hand-held strips (Fig. 7).

Many of the modalities discussed are commercially available in kits and some use autoclavable components affording re-use. When performing IPR a conservative approach with sequential removal of the desired amount of enamel is recommended. Finishing with extra fine grit materials to produce smooth surfaces is also advisable; this is essential to prevent plaque accumulation and demineralisation. Dental floss can be used to confirm smooth surfaces are present occluso-gingivally. During the procedure the magnitude of enamel removed can be gauged incrementally using

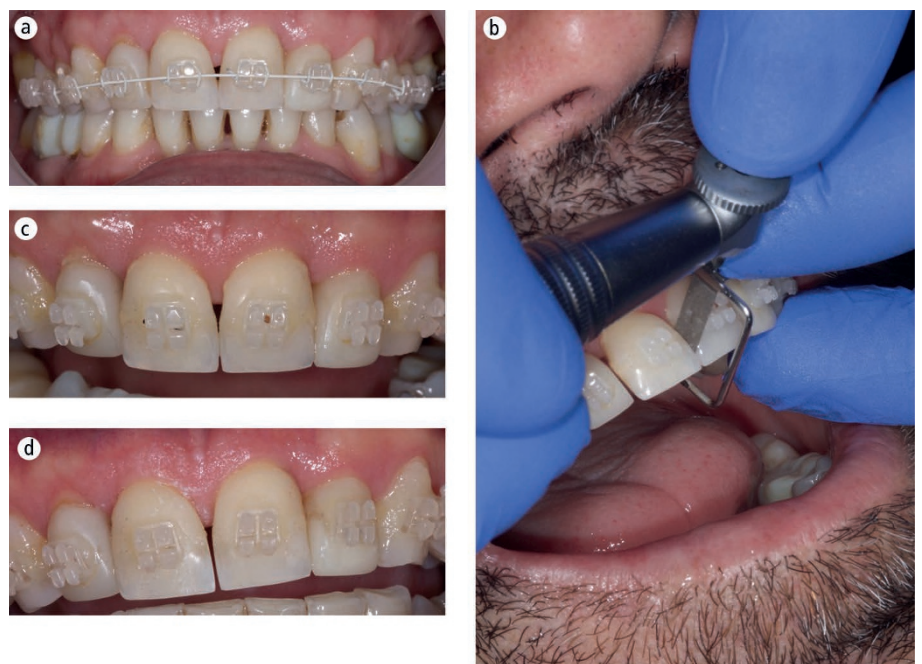


Fig. 6 (a-d) IPR used to gain space and reduce the appearance of black gingival triangles in the aesthetic zone. This was undertaken with oscillating mounted strips with increasing widths (Fig. 5c). Smooth interproximal surfaces are produced without ledges. The finger-rest position ensures maximum stability and control

bespoke gauges (Fig. 5f) or orthodontic wires of known dimensions. These may also serve a dual purpose of protecting the underlying soft tissues during mechanical removal of the enamel. Enamel reduction procedures generate frictional heat²⁸ which may have an adverse

effect on the pulp. A critical temperature rise of 5.5 °C has been shown to cause pulpal irritation.²⁹ Therefore, air or water-cooling is imperative during mechanical IPR and may require the assistance of a nurse.



Fig. 7 Triangular teeth and a history of periodontal disease have resulted in unaesthetic black gingival triangles; (a-c) orthodontic alignment was undertaken in conjunction with incremental enamel reduction involving both proprietary burs and hand-held finishing with strips; (d-f) in this instance, the IPR was undertaken purely to enhance crown shape as space was not required to achieve the orthodontic objectives. Adhesive restorations were placed prior to debonding to enhance the aesthetic outcome further obscuring the dark triangles (g-i). Thereafter, bonded retainers were placed (j, k) (Restorative work courtesy of Dr David Jones)

Conclusion

IPR is a valid treatment modality as part of comprehensive orthodontic treatment. It has gained popularity in view of the increasing trend towards non-extraction based treatment and the increasingly popularity of adult orthodontics. As with any orthodontic procedure, case selection is paramount and the selection of IPR over and above other space-generating procedures should be informed by formal space planning and thorough planning in relation to the final occlusal and facial

treatment objectives. A varied armamentarium is available to facilitate safe and precise IPR.

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