Enamel thickness of the posterior dentition: Its implications for nonextraction treatment

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Orthodontists typically create space by extracting teeth or expanding the dental arches. Because public opinion currently tends to resist extraction therapy and expansion may be unstable, a third possibility, interproximal reduction, should be given more consideration.[1] While it has been suggested that approximately 50% of interproximal enamel can be safely removed,[1-3] estimates of the *actual* amount of tooth structure that can be removed depend on accurate reference data for enamel thickness, which are presently unavailable.

Reference data for interproximal enamel thickness are limited. Most studies have focused on enamel thickness of the anterior teeth.[4,5] While Schillingburg and Grace[6] provide preliminary data for mesial and distal enamel thickness of the posterior teeth, their sample was small and they did not control for potential confounders (e.g., sex, age, ethnicity). Stroud and coworkers,[7] who showed that sexual dimorphism in posterior tooth size was due to differences in dentin thickness rather than enamel thickness, did not distinguish between mesial and distal enamel. There are presently no studies that demonstrate the amount of enamel necessary to protect the teeth against caries or sensitivity.

Interproximal enamel reduction may offer an attractive alternative to extraction therapy because it allows transverse arch dimension and anterior inclinations to be maintained. This study evaluates and describes mesial and distal enamel thickness of the permanent molars and premolars. The clinical implications will be discussed and one case will be presented.

Abstract

This study describes mesial and distal enamel thickness of the permanent posterior mandibular dentition. The sample comprised 98 Caucasian adults (59 males, 39 females) 20 to 35 years old. Bitewing radiographs of the right permanent mandibular premolars and first and second molars were illuminated and transferred to a computer at a fixed magnification via a video camera. Enamel and dentin thicknesses were identified and digitized on the plane representing the maximum mesiodistal diameter of each tooth. The results showed that there were no significant sex differences in either mesial or distal enamel thickness. Enamel on the second molars was significantly thicker (0.3 to 0.4 mm) than enamel on the premolars. Distal enamel was significantly thicker than mesial enamel. There was approximately 10 mm of total enamel on the four teeth combined. Assuming 50% enamel reduction, the premolars and molars should provide 9.8 mm of additional space for realignment of mandibular teeth.

Key Words

Enamel thickness • Permanent dentition • Caucasians • Interproximal reduction

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Table 1
Mesial (M) and distal (D) enamel thickness (mm) of the mandibular dentition (sexes combined).

Tooth	Aspect	Mean	SD	Min	Max
First premolar	M	0.99	0.21	0.49	1.65
	D	1.07	0.23	0.54	1.49
Second premolar	M	1.19	0.21	0.61	1.63
	D	1.22	0.22	0.60	1.78
First molar	M	1.28	0.23	0.74	1.87
	D	1.40	0.25	0.70	2.17
Second molar	M	1.29	0.20	0.94	1.84
	D	1.48	0.26	0.95	2.33
Total	M	4.67	0.59	3.64	6.56
	D	5.11	0.70	3.74	6.41

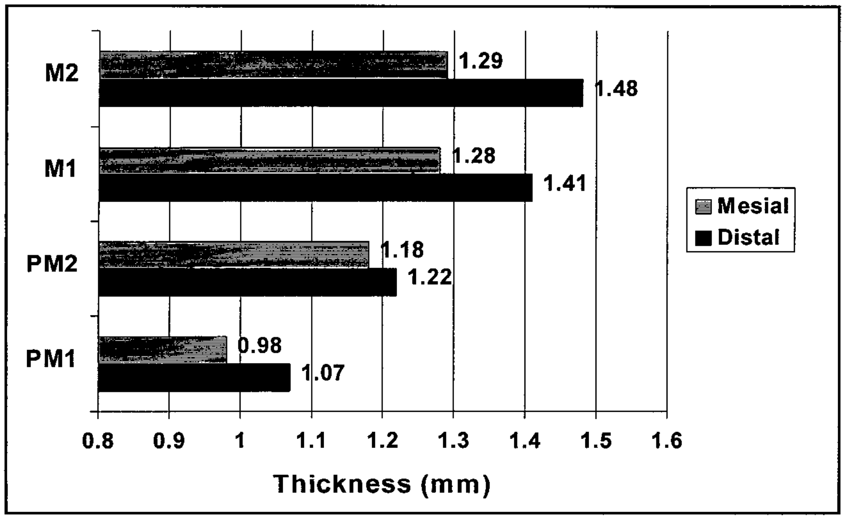

Figure 2

Figure 1

Figure 1
Landmarks for measurement of mesial and distal enamel thickness

Figure 2
Mesial and distal enamel thickness of the permanent premolars and molars measured along maximum tooth diameter

Materials and methods

Bitewing radiographs from 59 males and 39 females were evaluated. The median ages of the samples were 24.1 and 23.7 years, respectively, and the range was 20 to 39 years. All subjects were Caucasian and had complete dentitions. Subjects with restorations that interfered with the visualization of the enamel or dentin were excluded, along with individuals who had rotated molars or premolars.

Enamel thickness was measured on the right premolars and molars (excluding third molars). Bitewing radiographs were made using the Rinn XCP bitewing instrument (Rinn Corp, Elgin, Ill) and a dental X-ray machine, at 90KVp, 15 MA, and 30 impulses, with a distance of 305 mm between the target and the distal end of the position indicator device (PID). The distal plane of the PID was placed approximately 48 mm from the center of the occlusal plane and the film was located approximately 13 mm from the center of the occlusal plane. This geometry produces a magnification of 4%. Analysis showed little if any dimensional or shape distortion across individual films. Although positioning of the bitewing instrument may have varied between subjects, replicate analyses of 20 subjects showed that this accounted for only 0.2% of the variation. The radiographs were processed automatically in an Air Techniques Model KT 2000 processor using fresh Kodak chemistry, according to the manufacturer's instructions.

Enamel thickness was measured using a previously established technique.[8] The radiographic image was illuminated on a viewbox, captured with a video camera, and magnified (x10) on a display terminal. A Bioquant computer system (Bioquant Systems IV, R&M Biometrics, Inc, Nashville, Tenn) was used to manipulate the image, process the calculations, and correct for magnification. Four landmarks (Figure 1) were identified on the plane representing the tooth's maximum mesiodistal diameter. Mesial (A-B) and distal (C-D) enamel thickness was measured as the distance from the enamel contact points to the dentoenamel junctions. The measurements from each tooth were made on a single film. Replicate analyses of 14 randomly selected subjects showed no systematic error; random error ranged between 0.16 mm and 0.34 mm.

Skewness and kurtosis statistics indicated that all measures were distributed normally. *T*-tests were used to evaluate sexual dimorphism. Paired *t*-tests were used to compare mesial and distal enamel thickness.

Results

Sex differences in mesial and distal enamel thickness, ranging between 0.01 mm and 0.07 mm, were not statistically significant.

With the sexes combined, enamel thickness increased 0.3 mm to 0.4 mm between the first premolar and second molars (Table 1, Figure 2). Molar enamel was significantly ($p < 0.05$) thicker than premolar enamel. There was approximately 10 mm of total enamel on the four teeth combined.

Differences between mesial and distal enamel thickness of individual teeth ranged from 0.04 mm to 0.19 mm (Table 2). Except for second premolars, teeth demonstrated significantly greater thickness distally than mesially. Total distal enamel was 0.44 mm greater than total mesial enamel.

Table 2
Differences (mm) between mesial and distal enamel thickness of the mandibular dentition

Tooth	Mean Difference	SD	SE	*t*	Prob
First premolar	-0.09	0.24	0.03	-3.30	0.001
Second premolar	-0.04	0.23	0.03	-1.63	0.11
First molar	-0.12	0.26	0.03	-4.43	<0.001
Second molar	-0.19	0.26	0.03	-6.70	<0.001
Total	-0.44	0.59	0.07	-6.18	<0.001

Discussion

A lack of sex differences in enamel thickness has been reported previously.[5,7] The results showed that enamel becomes progressively thicker between the first premolar and second molar, indicating that the posterior teeth are subject to greater functional load.[9] Enamel thickness was consistently greater on the distal surface than on the mesial, which supports the findings of Shillingburg and Grace.[6]

The differences in mesial and distal enamel thicknesses were probably due to differential wear patterns. Only very low levels of mesial force are necessary to produce interstitial wear.[10-11] According to Wolpoff,[12] interstitial wear occurs as a result of lateral movement of the teeth and the mesial force vector. The lateral component of force occurs during mastication.[11,13] The mesial force vector has been associated with soft tissue pressures, eruptive pressures, the action of occlusion on the crowns, and occlusal forces. More importantly, the mesial inclination or tilt of the teeth could produce pressure points on the mesial surfaces, resulting in greater wear mesially than distally.

Based on the limited reference data previously available,[6] it has been estimated that approximately 6.4 mm space will be created if 50% of the enamel is removed from the eight buccal contacts. Our results indicate that this figure is a substantial underestimate of the amount of space that could be gained (Figure 3). Our data suggest that 9.8 mm might be expected with 50% enamel reduction of the premolars and first two molars. Even individuals at the lowest end of the distribution (i.e., those with the thinnest enamel) might be expected to gain over 7 mm with 50% enamel reduction. Our frequency distributions indicate that 95% of the sample could gain 7.3 mm or, and individuals in the upper quartile might be expected to gain more than 11 mm of space.

The potential iatrogenic effects of interproximal reduction include increased incidences of caries, periodontal disease, and temperature sensitivity. However, reduction of interproximal surfaces of the anterior teeth has not resulted in increased susceptibility to caries or periodontal disease.[3,14-17] Although Radlanski and coworkers[18] suggested an increase in caries with interproximal reduction of the posterior segment, Crain and Sheridan[19] did not find an increased 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 in these patients.[20] However, the closer distance between the roots of interproximally reduced teeth may predispose patients with inflammation to the more rapid progression of periodontal disease.

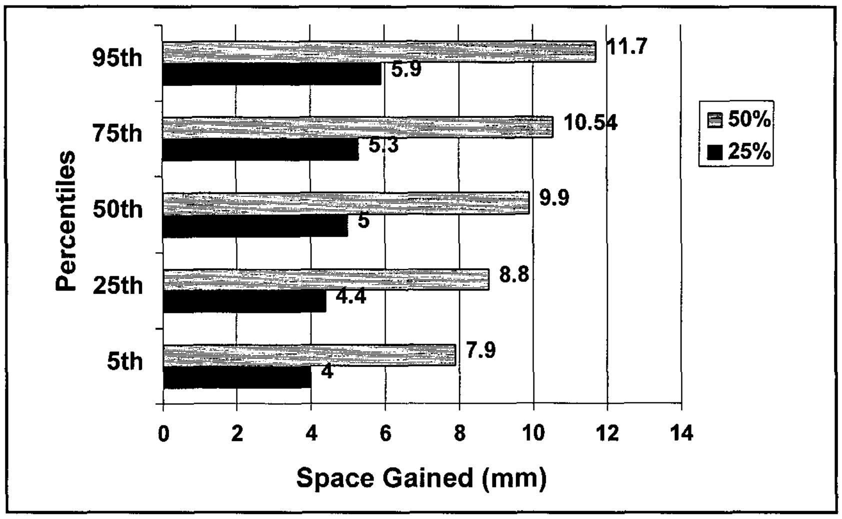

Figure 3

Figure 3
Percentile distribution of space gained with 25% and 50% enamel reduction

Interproximal reduction has been suggested as a preventive[21-22] or therapeutic measure.[23] Based on the foregoing, interproximal reduction may be indicated for individuals with:

(1) good oral hygiene
(2) Class I arch-length discrepancies with orthognathic profiles

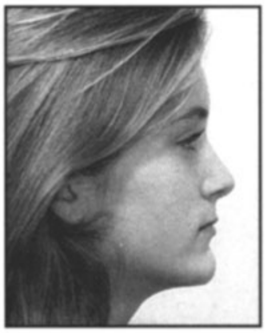

Figure 4A

Figure 4B

Figure 4C

Figure 4D

Case 1
Figure 4A-D
Case I pretreatment photos
A: Facial profile view
B: Frontal intraoral view
C: Maxillary occlusal view
D: Mandibular occlusal view

(3) minor Class II dental malocclusions (particularly nongrowing patients)

(4) Bolton tooth-size discrepancies

Interproximal reduction is particularly well suited for arch-length discrepancies less than the size of two premolars. When the 15 mm of arch length gained by extractions is more than is needed to resolve the arch-length discrepancy, interproximal reduction provides a more conservative approach that allows the orthodontist greater control of the space gained.

Case presentation

The patient was 16 years 4 months of age with a straight facial profile (Figure 4A) and a Class I malocclusion. The patient presented with maxillary crowding (4 mm), mandibular crowding (10 mm), a deep overbite, and an anterior crossbite of the maxillary right lateral incisor (Figure 4B-D). Additionally, both the maxillary and mandibular incisors were upright and the maxillary right first molar had extensive caries.

Treatment objectives

1. Resolve crowding in both arches.
2. Correct the crossbite of the maxillary right lateral incisor.
3. Improve the facial profile.
4. Establish normal overbite and overjet.
5. Establish a good interincisal angle.
6. Establish Class I molar and canine relationships.
7. Restore maxillary right first molar.

Treatment plan

1. Crown maxillary right first molar.
2. Attempt nonextraction treatment.
3. Band and bond both arches.
4. Use a removable biteplate to correct anterior crossbite of upper right lateral incisor.
5. Advance mandibular incisors to good angulation and establish a better interincisal angle.
6. Reduce mandibular crowding by 8 mm of interproximal enamel reduction.
7. Retain mandibular arch indefinitely with a bonded lingual 3-3 due to rotation and uprighting of mandibular canines. Retain maxillary arch with a wraparound Hawley retainer.

Interproximal reduction was performed on all buccal segments mesial to the second molars and in the anterior segment. Separators were placed between the teeth to improve access to the interproximal contact areas and to reduce the risk of cutting gingival tissue. A 699L crosscut fissure bur was used in the posterior areas, as described by Sheridan.[24] In the anterior area, a combination of flexible abrasive strips and the Dome Stripper (Dome Corp, Tarzana, Calif.) was used to remove smaller amounts of enamel.

As a result of treatment, anterior crowding was resolved in both arches. Eight mm of space was gained by means of interproximal reduction. Overjet and overbite were normal. A good interincisal angle was established by creating a proper axial inclination of both mandibular and maxillary incisors. Retention will be needed indefinitely in this case because the mandibular canines were rotated into position. Permanent retention is a reasonable price to pay for a better facial profile and a pleasing smile (Figure 5A-D).

Figure 5A

Figure 5B

Figure 5C

Figure 5D

Figure 5A-D
Posttreatment photos
A: Facial profile view
B: Frontal intraoral view
C: Maxillary occlusal view
D: Mandibular occlusal view

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