I J Pre Clin Dent Res 2015;2(3):15-22
July-September

International Journal of Preventive &
Clinical Dental Research

Comparitive Evaluation of Enamel Demineralisation using Conventional Light Cure Composite Resin and RMGIC- An Invivo Study

Abstract

Background: The risk of dental caries increases with the use of orthodontic appliances and its control cannot depend only on the patient's self care; this study evaluated the effect of resin modified glass ionomer cement on reducing enamel demineralization around the orthodontic brackets. **Method**: Fourteen patients undergoing orthodontic treatment scheduled to have premolars extracted for orthodontic reasons. In each patients split mouth design was used to accompany Fuji Ortho LC, a resin modified glass ionomer cement (experimental group) and the Transbond XT, a composite resin (control group) in right and left side respectively. 14 brackets were bonded for each group. After 30 days, teeth were extracted, sectioned and tested for demineralization. **Results:** The study showed that less enamel demineralization was found in enamel around the bracket cemented with glass ionomer compare with the composite resin. There was greater demineralization in the cervical area than in the occlusal area, and the demineralization was more in Transbond XT. There was significant different difference on the buccal side, Fuji Ortho LC showed highest hardness valve at 10μm from the surface of the enamel. There was no significant difference between the material hardness on the lingual side. **Conclusion:** Enamel demineralization was found to be less around the bracket cemented with resin modified glass ionomer in comparison with the composite resin. Therefore its use as a bonding agent in orthodontic treatment should be encouraged.

Key Words

Sealants; retention; school children; dental caries

Subramanya Shetty[1], Shourya Hegde[2], Kalavani[3], Ashith MV[4], Siddharth R[5]

[1]Senior Lecturer, Department of Orthodontics & Dentofacial Orthopaedics, Yenepoya Dental College, Deralakatte, Mangalore, India
[2]Reader, Department of Orthodontics & Dentofacial Orthopaedics, Yenepoya Dental College, Deralakatte, Mangalore, India
[3]Professor, Department of Orthodontics & Dentofacial Orthopaedics, CKS Teja Institute of Dental Sciences & Research, Tirupati, Andhra Pradesh, India
[4]Assistant Professor, Department of Orthodontics & Dentofacial Orthopaedics, Manipal College of Dental Sciences, Mangalore, Karnataka, India
[4]Senior Lecturer, Department of Orthodontics & Dentofacial Orthopaedics, Srinivas Institute of Dental Sciences, Mangalore, Karnataka, India

INTRODUCTION

Many benefits can be derived from orthodontic treatment, including improvements in a patients dental function, esthetics and overall self-esteem and attitude. However, the positive effects of orthodontic treatment can be overshadowed by demineralization of the tooth enamel adjacent to fixed orthodontic appliances; this is a compromise of both esthetics and oral health. Gorelick *et al.*, found non-developmental lesions in 50% of treated patients in contrast to 25% of untreated controls. In another, study, 97% of the patients developed lesions during treatment.[1] Demineralization of the enamel around the bracket is an undesired side effect with high clinical relevance. During orthodontic treatment, plaque accumulates around the brackets because of inadequate oral hygiene, which is common in pubertal young people. Demineralization can result within a few weeks, a length of time that is usually shorter than that preferred by most orthodontists.[2] Composite resins are predominantly used to bond orthodontic brackets to teeth. However the presence of a bracket and any resin flash around it predisposes to plaque accumulation, with increased risk of demineralization of the surrounding enamel.

Research has demonstrated that plaque more readily accumulates on composite resin adhesive than on enamel. This can lead to demineralization of the enamel surrounding brackets with resulting white spot lesions adjacent to the resins. The extent of these lesions includes incipient and carious lesions that may require restoration. O'Reilly and Featherstone reported that measurable demineralization occurs around orthodontic bands and brackets as early as 1 month after the start of treatment. The increase in enamel demineralization can be attributed in part to increase in plaque around orthodontic brackets because of increased difficulty in plaque removal as well as increased bacterial adhesion to composite resin bonding materials. Studies have documented significant increase in oral bacteria during orthodontic treatment.[3] Methods shown to decrease white spot lesion include improving oral hygiene, modifying the diet to decrease the amount of fermentable carbohydrates, and applying topical fluoride treatment. These methods, however, rely on patient compliance.[4] Various methods of decreasing demineralization have been examined that do not require patient compliances. Fluoride varnishes are an option that allows the orthodontist to control the timing and the amount of fluoride used.[1] Fluoride varnishes have also been shown to decrease enamel demineralization in vitro and in clinical trials. Fluoride varnishes have the benefit of adhering to the enamel surface longer than other topical fluoride products. Thus, fluoride varnishes have been reported to be superior to sodium fluoride and monoflourophosphate dentifrices in their ability to increase fluoride uptake in enamel. An increase was also found after 3 weeks when comparing fluoride varnish with 2% sodium fluoride gel applied weekly, 2% acidulated phosphate fluoride gel applied weekly, or 0.25% sodium fluoride rinse used daily. Application of fluoride varnishes is extremely easy. It has been shown that thorough prophylaxis is not required, but it is best to dry the area before applying the varnish.[4] However, varnishes require several in office applications and are generally applied only after lesions are found to prevent their progression. Previous investigations have examined the effectiveness of the resin sealants to protect the enamel surface. Both chemical and light cured products have been examined with only mediocre results. Due to oxygen inhibition at the surface, chemical cure systems failed to reach complete polymerization. This results in a thin or often non-existent, layer remaining. Light cure resins, although still suscpectible to some oxygen inhibition at the surface, reach a higher degree of polymerization and offer more complete coverage than chemical cure products. Unfortunately, the unfilled or lightly filled resins with the desired low viscosity and high flow ability to facilitate application, lack the strength to resist abrasion over an extended period of time.[1] Flouride releasing bonding agents have the potential to minimize demineralization around orthodontic brackets. The critical factors for success of these materials are adequate bond strength for orthodontic appliances and sustained fluoride release.[3]

OBJECTIVES OF THE STUDY

The light of above mentioned factors this study has been planned with the following aims and objective

1. To evaluate enamel demineralization.
2. To assess anti-cariogenic effect.

MATERIALS AND METHODS

The study was carried out in the Department of Orthodontics and Dentofacial Orthopedics, CKS Teja Institute of Dental Science and Research Tirupathi to evaluate the in vivo effect of resin modified glass ionomer cement in reducing dental caries and enamel demineralization around orthodontic brackets. We have selected 15 patients, 15-25 years of age, who had come to the Department of Orthodontics, CKS Teja Institute of Dental Science and Research, Tirupathi for ortho treatment. Criteria for selection were:

1. No active caries was present.
2. Patients with a normal salivary flow.
3. Patients with a normal buffer capacity of saliva (final PH between 6 and 7).
4. No fluorosis
5. No attrition or abrasion
6. Patient who needed extraction of 1st premolar as a part of their Orthodontic treatment protocol.

The brackets used for this study were 3M UNITEK MBT .022" slot first premolar brackets of the respective sides (Fig. 2). In fifteen patients, maxillary 1st premolar were bonded with RMGIC (Fuji LC Fig. 3a, Fig. 3b & Fig. 3c) on the right side and with a conventional composite resin (Transbond XT Fig. 4) on left side. The etchant (Transbond Fig. 5) was used to prepare the teeth before bonding. The manufacturer's recommendations were followed. Excessive adhesive around the brackets was removed and then brackets were subjected to light cure. Patients were not given any special instructions regarding oral hygiene maintenance. They were told to brush with non-fluoridated tooth paste. Salivary flow and buffer capacity were also determined using a "Saliva Check" from GC (Fig. 6). They had no active caries and salivary flow was normal. After 30 days the teeth were extracted with the bracket intact and stored in a refrigerator in a glass specimen bottle containing 2% formaldehyde (Fig. 7), ph-7, until the analysis. The extracted teeth were longitudinally sectioned into 2 halves, in the bucco-palatal direction, through the centre of the bracket using a carborandum water cooled disc. The split half crown sections were embedded in acrylic (Fig. 8). The surfaces were grounded using belt grinders. The sample was polished using different grades of emery paper such as 1/0, 2/0, 3/0 and 4/0 final polishing was done using alumina powder suspension and polishing cloth. Dental caries in enamel around the bracket was evaluated by cross–sectional micro hardness testing. Micro hardness tester with a Knoop diamond (Fig. 9) under a 10 gram load for 5 seconds was used for micro hardness analysis. Koop hardness was calculated by the formula $KHN = 1.854P^2/d$.

P= load, d=mean diagonal length indentation

Forty indentations were made. On the buccal surface indentations were made inferior and superior to the bracket (Fig. 1). In the occlusal and cervical region, indentations were made at the edge (0) of the bracket and at the 100 and 200 µm away from it. An indentation was also made in the middle third of the lingual surface of each half crown, as a control. At 0, 100 and 200 µm on the buccal surface and at the middle third of the lingual surface five indentations were made at a depth of 10, 20, 30, 60 and 90 µm. Cross-sectional microhardness testing was used to evaluate demineralization, because there is a good correlation between enamel micro hardness and % of mineral caries lesion. Analysis of variance (ANOVA) was used to evaluate the effect of the materials (Fuji Ortho LC and Transbond XT) at a depth from the enamel surface (10, 20, 30, 60 and 90 µm) position (under the bracket, on the buccal surface, in occlusal and cervical region at 0, 100 and 200µm from the bracket and on the lingual surface) and these interactions. ANOVA was followed by Tukey test for the analysis, statistics for SPSS version 11.5 was used and the statically significance was set at p= 0.05(Fig. 10).

RESULTS

ANALYSIS OF DATA

Analysis of Variance (ANOVA) was used to evaluate to assess the effect of material (experiment and control) in depths (10, 20, 30, 60 and 90um) position. Table 1 shows that there is a significant interaction between the depths in experiment group (F- ratio= 243.896, P<0.001) and control group (F ratio = 258.987, P<0.001).This means that there was a significant difference between the mean scores of depths. To study the multiple comparisons was analysed Tucky Post hack test. In experiment group there is a significant difference (P<0.001) in all depths except depth 60 and depth 90. It was found that there was a significant difference (P<0.001) in all depths in control group except depth 30, depth 60 and depth 90. Table 2 shows that there is a significant difference between the control and experiment groups in depths (10, 30, 60 and 90) (p<0.001) and there is no significant difference between the control and experiment groups in depth 20 (p>0.05). The mean standard deviation and significant difference between the control and experiment groups was presented in Table 3. It was found that there was a significant difference in occlusal 0,200 (p<0.05) and cervical 0,100 and 200. There is no significant difference in occlusal 100, under and lingual (p>0.05) between control and experiment groups. Table 4 shows that there was a significant differences (p<0.05) in all groups except under, cervical10 and lingual groups.

DISCUSSION

Orthodontic therapy with fixed intraoral appliances frequently makes the patient's habitual oral hygiene more difficult. The accumulation of dental plaque adjacent to the brackets and bands increases the patient's risk of caries, and the white spot lesion at the end of corrective therapy are frequent.[6] Because the risk of dental caries increases with the use of orthodontic appliances and its control cannot depend only on patient's self-care, this study evaluated the effect of a RMGIC on reducing enamel demineralization around orthodontic brackets. Resin-modified glass ionomer cements (RMGIC) were developed to overcome the problems of moisture sensitivity of composites and the low early mechanical strength of glass ionomer, while maintaining the clinical advantages of conventional glass ionomer, such as fluoride release, chemical bond to enamel, and adhesion in a wet field[7]. Fluoride releasing bonding agents was developed to allow for compliance-free, constant

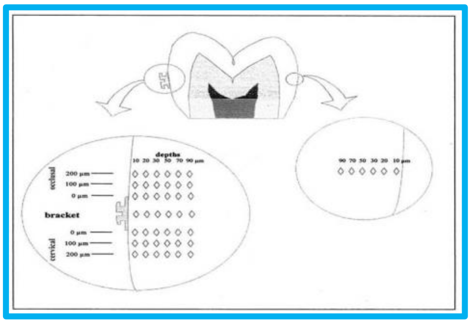

Fig. 1: Diagrammatic representation of positions


Fig. 2: Metal premolar brackets

Fig. 3a: RMGIC

Fig. 3b: RMGIC-powder

Fig. 3c: RMGIC-liquid


Fig. 4: Transbond XTs

Fig. 5: Etchant

Fig. 6: Saliva check

exposure to topical fluoride. In late 1980's, glass ionomer cements were proposed as an alternative to the more commonly used composite material for bracket bonding.[8] First generation glass ionomer cements had an extended early setting stage, during which the materials were highly soluble. Second generation glass ionomer had shorter initial setting time. Because of their weaker shear bond strength, the 2nd generation glass ionomer cements not advocated for direct bonding of orthodontic brackets. Recently, a light-cured resin reinforced glass ionomer, Fuji Orthod LC, was introduced as an alternative direct bonding agent. Three reaction occur and are required for the complete setting of this adhesive: 1) traditional glass ionomer acid-base reaction; 2) light activated radical polymerization of HEMA and two other polymer to form poly HEMA matrix and; 3) self cure resin monomers.[9] Voorhies *et al.*,[3] demonstrated that less enamel demineralization occurred when using a fluoride-releasing hybrid GIC compared with a resin ionomer or a resin control. These findings suggest that RMGIs have potential cario-preventive ability. Any potential benefit of fluoride containing

Fig. 7: Glass specimen


Fig. 8: Split half crown section embedded in acrylic


Fig. 9: Micro hardness tester

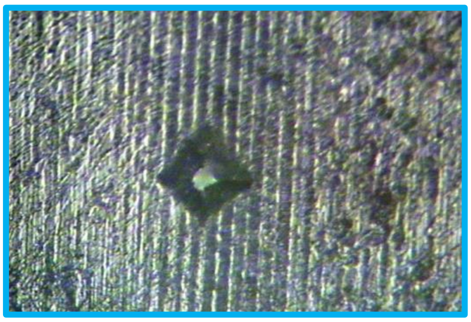
Fig. 10: Diamond shaped indentation displayed on the monitor and the diagonals are measured

Table 1

EXPERIMENTAL GROUP

	N	mean	Std deviation	F	Sig
10	15	252.183	12.387		
20	15	280.525	11.052		
30	15	330.267	13.893	243.896	0.000
60	15	345.442	5.796		
90	75	348.292	7.859		
Total	75	311.342	39.921		

CONTROL GROUP

	N	Mean	Std deviation	F	Sig
10	15	238.300	6.971		
20	15	269.642	21.714		
30	15	342.817	11.167		
60	15	354.308	11.443	258.987	0.000
90	15	360.983	10.906		
Total	75	313.210	51.713		

orthodontic bonding materials depends on the actual fluoride release from these materials. Light cured orthodontic material have been shown to have fluoride release rates that could theoretically inhibit enamel decalcification based on the proposed effective range for inhibition of enamel demineralization of 0.65 to 1.3µ*g* F/cm2/day. The potential ability of fluoride release and absorption of orthodontic adhesives has attracted considerable interest as a possible means of preventing peribracket enamel demineralization.[10] The present in vivo study evaluated the effect of bonding materials on caries in enamel adjacent to brackets. Mineral loss was assessed in vitro by cross sectional micro hardness, a recognized analytical method. Fifteen Orthodontic patients who needed extraction of maxillary 1st premolar participated in this study (Table 1). All the patients were examined clinically and radiographically. Patients were selected with caries free, fluorosis free teeth without abrasion or attrition. Salivary flow and buffer capacity were also determined. Orthodontic bracket with resin modified glass ionomer cement on right side maxillary 1st premolar were bonded and with composite on left side (control group). The split-mouth design was preferred to minimize individual

TUKEY HSD

EXPERIMENTAL

(I)DEPTH	(J)DEPTH	an difference	P value
10	20	-28.342	0.000
	30	-78.083	0.000
	60	-93.258	0.000
	90	-96.108	0.000
20	30	-49.742	0.000
	60	-64.917	0.000
	90	-67.767	0.000
30	60	-15.175	0.002
	90	-18.025	0.000
60	90	-2.850	0.948

CONTROL

(I)DEPTH	(J)DEPTH	an differential	P value
10	20	-31.342	0.000
	30	-104.517	0.000
	60	-116.008	0.000
	90	-122.683	0.000
20	30	-73.175	0.000
	60	-84.667	0.000
	90	-91.342	0.000
30	60	-11.492	0.141
	90	-18.167	0.004
60	90	-6.675	0.651

TABLE 2

DEPTH	COD1	N	Mean	Std. Deviation	Z	p value	sig
10	EXP	15	252.183	12.387	3.783	0.001	sig
	CONT	15	238.300	6.971			
20	EXP	15	280.525	11.052	1.730	0.095	ns
	CONT	15	269.642	21.714			
30	EXP	15	330.267	13.893	-2.727	0.011	sig
	CONT	15	342.817	11.167			
60	EXP	15	345.442	5.796	-2.677	0.012	sig
	CONT	15	354.308	11.443			
90	EXP	15	348.292	7.859	-3.657	0.001	sig
	CONT	15	360.983	10.906			

TABLE 3

	COD	N	Mean	Std. Deviation	Z	p value	sig
OCC0	EXP	15	357.933	10.430	-2.273	0.031	sig
	CONT	15	367.533	12.603			
OCC100	EXP	15	349.467	13.217	-1.956	0.060	ns
	CONT	15	358.800	12.913			
OCC200	EXP	15	334.800	9.359	-3.628	0.001	sig
	CONT	15	352.333	16.211			
UNDE	EXP	15	361.933	14.002	-1.808	0.081	ns
	CONT	15	369.800	9.382			
CER0	EXP	15	325.400	15.797	-3.658	0.001	sig
	CONT	15	349.067	19.451			
CER100	EXP	15	336.200	14.635	-3.801	0.001	sig
	CONT	15	357.400	15.887			
CER200	EXP	15	352.800	11.918	-3.139	0.004	sig
	CONT	15	368.533	15.320			
LING	EXP	15	367.800	5.979	1.846	0.075	ns
	CONT	15	364.400	3.888			

Table 4: Mean, SD for materials and positions at depth of 10um

Interaction of material/placement/depths	COD	N	Mean	Std. Deviation	Z	p value	sig
OCC0	EXP	15	261.400	19.283	5.265	0.000	sig
	CONT	15	233.133	7.782			
OCC100	EXP	15	236.267	24.197	2.663	0.013	sig
	CONT	15	218.867	7.405			
OCC200	EXP	15	233.200	45.102	2.204	0.036	sig
	CONT	15	207.133	7.999			
UNDE	EXP	15	266.333	18.715	1.477	0.151	ns
	CONT	15	256.133	19.101			
CER0	EXP	15	219.933	21.406	1.480	0.150	ns
	CONT	15	210.267	13.483			
CER100	EXP	15	224.533	9.007	2.109	0.044	sig
	CONT	15	216.467	11.759			
CER200	EXP	15	250.000	16.436	2.494	0.019	sig
	CONT	15	236.200	13.749			
LING	EXP	15	325.800	4.296	-1.680	0.104	ns
	CONT	15	328.200	3.489			

variations inherent to clinical studies. The carry-across effect due to fluoride release by the glass ionomer cement on enamel around the bases bonded with composite resin was not observed because the effect of material was statistically significant, and greater demineralization was found in enamel adjacent to the composite in comparison with the ionomeric material.[13] The patients did not know what bonding material was used (blind study): they brushed their teeth with a non-fluoridated dentifrice. They received no instructions regarding oral hygiene, kept their usual habits, and received instructions not to use a mouth rinse. Similar oral conditions were present for both materials as both materials were tested in the same patient. The exerimental period of 4 weeks was used because measurable demineralization can be observed under orthodontic appliances 1 month after bonding.[13,14] In the occlusal and cervical regions the indentations were made at the edge (0) of the bracket and at 100 and 200 μm away from it . The indentations were made in the middle third of the lingual surface of each half of crown in all these positions, 5 indentations were made at 10, 20, 30, 60 and 90μm from the external surface of the enamel to observe mineral changes at the outer most part of the enamel. Two internal controls (under the bracket and at the lingual surface) were used to evaluate the effect of acid etching. Regarding the additional controls, the findings showed that the enamel demineralization might be attributed to the experimental material evaluated. Thus the micro hardness of the enamel under the brackets bonded with Fuji Ortho LC was statistically similar (Table 3), showing that the results regarding demineralization are due to caries and not to the effect of the material. Also, the results found on two sides were similar, because the enamel hardness was statistically similar (Table 3). The finding in the Table 2 showed that narrow caries lesion (up to 30μm depth) developed adjacent to material, but statistically significant differences between the two sides were found at distance of 10 and 20μm from the enamel surface. The mineral loss in the enamel was 33% adjacent to the composite resin and 21% adjacent to the glass ionomer. Thus, Fuji Ortho LC reduced enamel demineralization adjacent to brackets by 12%. The mineral loss adjacent to Transbond XT agrees with the results of O' Reilly and Featherstone,[15] who found 15% mineral loss at the 25μm depth. The effect of Fuji Ortho LC agrees with in vitro data observed with this material and other glass ionomer cements for orthodontic bonding.[15] The data in Table 3 shows two relevant aspects about dental caries of the material in reducing demineralization. First, enamel hardness was less around the composite resin in the cervical area when compared with occlusal area. This is because of greater accumulation of plaque and patients difficulty to clean this area. This higher mineral loss in the cervical region than in the occlusal area has been observed by Czochrowska E *et al.*,[16] in vitro. Also this is due to lower mineralization and higher carbonate on the cervical face than in the occlusal region. The second consideration about the finding in Table 3 is the statistically significant difference between the material at p=0.05 were observed in cervical area, but not in the occlusal region. Thus, the effect of Fuji Ortho LC in reducing enamel demineralization adjacent to the bond is more evident in the cervical area. This shows the effect of this material also occurs on the tooth surface where the patient has difficulty in cleaning dental plaque with a tooth brush. This effect is due to the fluoride releasing ability of glass ionomer cements when submitted to cariogenic challenges.[17] This result is in agreement with Reneta[6] and Carvalho[17] who found that it decreases the development of caries around orthodontic brackets. The data in the Table 4 shows that at 10µm from the surface, the only position with significant difference between the materials was the on the lingual surface. The difference in the enamel hardness under the bracket bonded with Transbond XT Fuji Ortho LC is due to acid etching during bonding with the resin. This effect was also described by O'Reilly and Featherstone.[15] They found a mineral loss of 3% to 8% directly under the brackets retained with composite resin. Nevertheless, the reduced hardness in enamel adjacent to the brackets cemented with the Transbond XT in comparison with those with Fuji Ortho LC can be attributed to dental caries and not to acid etching. This is clear because Fuji Ortho LC reduces enamel demineralization not only at the edge of the bracket 0 but also at 100 and 200 µm away from it. The study showed that less enamel demineralization was found in enamel around in enamel around the bracket cemented with glass ionomer in comparison with the control. There was greater demineralization in the cervical area than in occlusal area, and the demineralization was more in Transbond XT. There were significant differences on the buccal side, Fuji Ortho LC showed highest hardness value at 10µm from the surface of the enamel.

CONCLUSION

Enamel demineralization was found to be less around the bracket cemented with resin modified glass ionomer in comparison with the composite resin. Therefore its use as a bonding agent in orthodontic treatment should be encouraged.

REFERENCES

1. Buren JL, Staley RN, Wefel J, and Qian F. Inhibition of enamel demineralization by an enamel sealent , Pro Seal: An in-vitro study. Am J Orthod Dentofacial Orthop 2008;133:S88-94.
2. Paschos E, Kleinschrodt T, Clementino-luedemann T, Huth KC, Hickel R, Kunzelmann K-H, Rudzki-Janson I. Efect different bonding agents on prevention of enamel demineralization around orthodontic brackets. Am J Orthod Dentofacial Orthop 2009;135:603-12.
3. Vorhies AB, Donly KJ, Staley RN, Wefel JS. Enamel demineralization adjacent to orthodontic brackets bonded with hybrid glass ionomer cements: an in vitro study. Am J Orthod Dentofacial Orthop 1998;114:668-74.
4. Schmit JL, Staley RN, Wfel JS, Kanellis M, Jakobsen JR, Keenan PJ. Effect of fluoride varnish on demineralization adjacent to brackets bonded with RMGI cement. Am J Orthod Dentofacial Orthop 2002;122:125-34.
5. Wright AB, Robert T, Edward lynch, Young KA. Clinical and microbiologic evaluation of resin modified glass ionomer cement for orthodontic bonding. Am J Orthod Dentofacial Orthop 1996;110:469-75.
6. Pascotto RC, lima Navarro MF, Filho LC, Cury JA. In vivo effect resin modified glass ionomer cement on enamel demineralization around orthodontic brackets. Am J Orthod Dentofacial Orthop 2004;125:36-41.
7. Cacciafesta V, Sfondrini MF, Calvi D, Scribeante A. Effect of fluoride application on shear bond strength of brackets bonded with resin modified glass ionomer. Am J Orthod Dentofacial Orthop 2005;127:580-3.