All- Ceramic Crown Preparation and the Remained wall Thickness of the Pulp Chamber

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KEY WORDS
All-Ceramic;
Crown Preparation;
Pulp Chamber;
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ABSTRACT

Statement of Problem: A minimally invasive method of preparation is essential to prevent tooth structure weakening and pulp irritation; especially for mandibular anterior single-tooth all-ceramic crowns. According to many investigations, one of the most important reasons of pulp injury caused by tooth preparation for different restorative procedures is reduced "remained wall thickness" (RWT). In order to protect the pulp from irritation, it is necessary to maintain a 0.5 mm of RWT.

Purpose: The purpose of the present study was to evaluate the effect of all-ceramic crown preparation on pulp chamber RWT of mandibular incisors.

Materials and Method: Mesiodistal and buccolingual initial images of 24 extracted mandibular incisors were provided. The pulp chamber initial wall thicknesses of buccal, lingual and proximal surfaces of cervical, 1and 2 mm above the cervical areas and also the incisal surfaces of incisal sections were measured using digital radiography and Photoshop software. After all-ceramic crown preparation, images were provided at the same initial positions. The initial and remained pulp chamber wall thicknesses were statistically evaluated and analyzed by ANOVA, paired t-test and a post hoc Tukey test.

Results: Repeated measures ANOVA showed that the mean of pre- or post-preparation wall thicknesses were not significantly different for each surface at the three horizontal levels ($p > 0.05$). However, there were significant differences between the surfaces for each section. Comparison of pre- and post-preparation wall thicknesses revealed significant differences ($p < 0.05$). Proximal surfaces of cervical sections had the least RWT (0.42±0.12).

Conclusion: According to the results of the present study, the least amount of initial and remained wall thicknesses of pulp chamber were related to the proximal surfaces, particularly in cervical areas. Therefore a reduction of preparation to 0.7 mm is suggested to prevent future pulp injury for mandibular incisors of 35 to 40-year- old patients and younger who require all-ceramic crown preparations.

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Introduction

A minimally invasive method of preparation is essential to prevent tooth structure from weakening and pulp irritation; especially for mandibular anterior single-tooth all-ceramic crowns [1-6].

According to many investigations, one of the most important reasons of pulp injury caused by tooth preparation in different restorative procedures is reduced RWT [7-10], which can result in the subsequent inflammation and necrosis of the pulp [11-12].

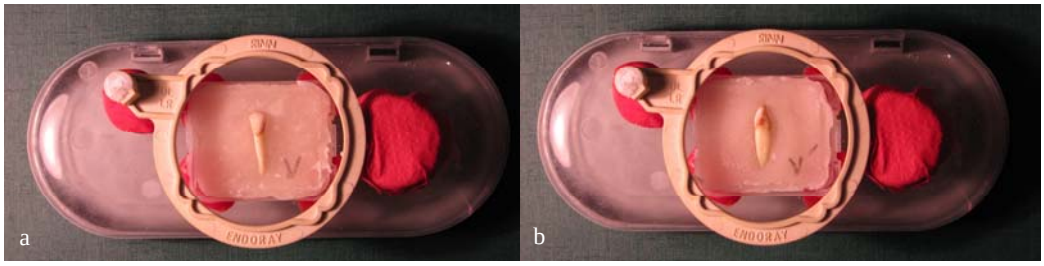

Figure 1a Constant and reproducible position in buccolingual **b** and mesiodistal (upper right) directions for providing the pre-preparation images of a sample.

Many studies have evaluated the pulp and periapical status of crowned teeth [4-6, 13-19] but few have considered the interaction between RWT and pulp injury [8-9, 20-24]. When the RWT is less than 0.5 mm, more reactionary dentine will be produced [9]. The maximum amount of reactionary dentine is formed when there is a wall thickness of 0.25-0.5 mm [8]. In order to protect the pulp from irritation, it is necessary to maintain a minimum of 0.5 mm RWT [22]. Less pulpal reactions are observed when RWT is more than 1 mm [23]. Pulp is less irritated with the RWT of 1 mm, compared to an RWT of 0.5 mm [24]. According to Christensen, in an all-ceramic preparation procedure operated on a young vital tooth with large pulp, all aspects are subjected to a 1– 1.5-mm reduction in thickness except for occlusal aspect that is subjected to a reduction of 1.5– 2 mm [25]. The number of odontoblasts is one of the parameters involved in the repair of the dentine after restorative treatment, and RWT has a significant influence on the number of underlying odontoblasts [21]. Because of the limited circulation of pulp chamber, biological stimulants, such as decreased RWT, would lead to irreversible pulpitis [26]. The purpose of this study was to evaluate the effect of all-ceramic crown preparation on the pulp chamber wall thickness of extracted mandibular incisors.

Materials and Method

In this quasi experimental study a hundred human mandibular incisors, extracted as a result of periodontal disease, were collected from patients with the age range of 35 to 45. The teeth had no caries, attrition, external resorption, cracks and fractures. The teeth were disinfected by 5.25% NaOCl (Golrang co, Tehran, Iran) for 30 minutes and were stored in a normal saline solution till the time when the preparation procedures were carried out. All the teeth were radiographed, using the parallel technique. The samples with internal resorption or without pulp chamber were excluded from the study. Finally, 24 teeth were selected.

Impressions of mesiodistal and buccolingual dimensions of each tooth were taken using immediate acrylic resin. To maintain a constant and reproducible position to the rim of Endoray II (DENTSPLY, Elgin, IL, USA), usually employed in parallel technique, they were randomly numbered. The baseline radiographs (Figure 1) were taken in mesiodistal and buccolingual directions, for each sample, using Digora Optime Cordless phosphor plate digital radiography (Sordex, Tussula, Finland), and an X-ray machine [CSN Industry, Cinisello B. (MI), Italy]. The radiographic cone was 22.9 cm long and 6 cm in diameter. The exposure time was 0.14 seconds. The pre-preparation images of each

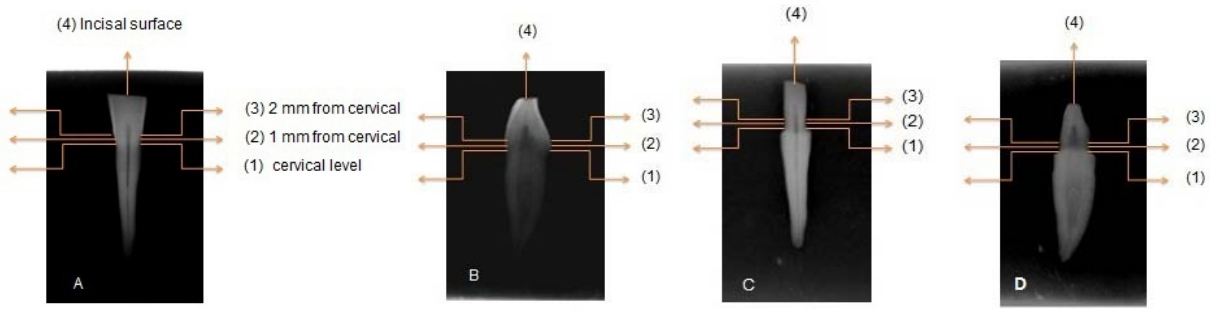

Figure 2a Pre-preparation X-ray image of a sample in buccolingual direction **b** Pre-preparation X-ray image of a sample in mesiodistal direction **c** Post-preparation X-ray image of a sample in buccolingual direction **d** Post-preparation X-ray image of a sample in mesiodistal direction

Table 1 The means and standard deviations of pulp chamber wall thicknesses for buccal, lingual and proximal surfaces before and after preparation at cervical area,1 mm and 2 mm above the cervical area in millimetre (N=24)

	Before			*P* value	After			*P* value
Section surface	**Cervical**	**1 mm above the cervical**	**2 mm above the cervical**		**Cervical**	**1 mm above the cervical**	**2 mm above the cervical**	
buccal	1.8±0.24	1.99±0.2	1.85±0.44	0.26	0.89±0.22	0.96±0.21	1.01±0.37	0.15
lingual	2.02±0.3	2.14±0.27	2±0.52	0.25	0.94±0.23	1±0.26	0.98±0.33	0.49
proximal	1.25±0.14	1.31±0.12	1.37±0.31	0.13	0.42±0.12	0.45±0.12	0.47±0.15	0.12
P Value	<0.001	<0.001	<0.001		<0.001	<0.001	<0.001	

tooth with their numbers in two directions were saved in a computer.

The pulp chamber wall thickness was defined by the distance from the outer surface of tooth crown to the border of the pulp chamber in the same horizon at three levels of cervical, and 1 and 2 mm above the cervical area. In the incisal sections, the distance between the middle roof of the pulp chamber and the incisal level was considered as the incisal thickness (Figure 2). The wall thickness was measured for incisal surface of incisal section and also buccal, lingual and proximal surfaces (the mean thicknesses of mesial and distal surfaces) of three aforementioned horizontal levels using Adobe Photoshop CS3 software (Adobe System Incorporated, San Jose, CA, USA) with0.1 mm accuracy.

Then the teeth were separately preserved in 0.9% normal saline solution. A ball bearing was used to determine the amount of magnification. The real dimensions were measured using a calliper and were compared to those in the radiographs. Comparisons showed no magnification.

All-ceramic shoulder crown preparation (1 mm in depth with a 6° convergence [27-28]) was performed with a high-speed handpiece and an 0.08 flat-end tapered diamond bur (Cavo, Germany) by a senior undergraduate student under supervision of a Prosthodontist in Fixed Prosthodontic department of the Dental Faculty, Islamic Azad university, Tehran, Iran. Since the tapering of the bur was the same as the tapering of preparation, depth and degree of tapering was evaluated by placement of the bur parallel to longitudinal axis, around the prepared tooth.

Post-preparation radiographs were taken using exactly the same baseline positions, and dentine thickness measurements were carried out. One bur was used for every 5 samples and a senior undergraduate student measured all of the thicknesses two times for each surface using the ruler of Adobe Photo Shop software and the mean value of the measurement was reported. In order to compare the pre- and post- measurements and the wall thickness of different sections, parametric tests like repeated measures ANOVA, post hoc Tukey test and paired t-test were used.

Results

Regarding the primary wall thickness, Kolmogorov-Smirnov test showed that distribution of the samples followed the normal distribution curve ($p> 0.05$).

Repeated measures ANOVA showed that the mean of pre- or post-preparation wall thicknesses of each surface were not significantly different at the three horizontal levels ($p> 0.05$). Comparison of the initial and remained wall thicknesses in different sections and surfaces exhibited significant differences and the least amount of the RWT was observed in the proximal surfaces of cervical level (0.42±0.12 mm). Table 1 and 2 shows the mean of initial and remained wall thicknesses of the pulp chamber.

Table 2 The mean and standard deviation of the pulp chamber wall thicknesses before and after preparation of incisal surface in millimetre (N=24)

	Before		After	
Section	**Incisal**	**P value**	**Incisal**	**P value**
buccolingual	3.76±0.8	0.78	2.28±0.085	0.001
mesiodistal	3.7±0.85		1.57±1.15	

Paired t-test illustrated that the initial wall thicknesses of the incisal surfaces were not significantly different in mesiodistal and buccolingual X-ray directions ($p> 0.05$). However, the RWT of this level were significantly different. The mean wall thickness was more in the buccolingual than mesiodistal dimension ($p< 0.001$).

Discussion

Due to the widespread use of prostheses nowadays, particularly all-ceramic crowns, evaluation of the effect of these preparations on pulp vitality is necessary [1].

The results of this study highlight the effect of all-ceramic crown preparations on the RWT of the pulp chamber in mandibular incisors for following reasons: a) small dimension of enamel and dentine thickness, b) the importance of these teeth in aesthetic considerations, and c) in case of failure, removal of all-ceramic crowns without damaging the tooth is almost impossible.

To assess the effect of all-ceramic preparations on the wall thickness of pulp chamber, the pre- and post-preparation radiographs were provided using cordless phosphor-plate digital radiographs taken with the parallel technique and the initial and remained wall thicknesses were measured using Adobe Photoshop CS3 software. In studies of Murray et al. [8-9] and Zollner et al. [10] the measurements were carried out using an electron microscope. In this study, the initial and remained pulp chamber wall thicknesses of mandibular incisors were evaluated within a limited age range. Only a few studies [8-9, 20-24] have considered this issue. This study assessed the pulp chamber wall thicknesses in various surfaces in four sections.

To determine the magnification of digital radiography with the parallel technique, we compared the measurement of real calibre of a ball bearing with a digital one. The measurements were the same so the phosphor- plate digital radiography did not show any magnification. To provide an identical position in pre- and post-preparation X-rays, immediate acrylic resins were used to reduce minimum dimensional changes.

In this study RWT was not evaluated in the same conditions as in Murray's study and the results may be more accurate because of the all-ceramic shoulder crown preparation and evaluation of all the surfaces.

The pulp chamber wall thicknesses were measured at three horizontal levels (cervical, 1 mm and 2 mm above the cervical area) for buccal, lingual and proximal surfaces and also vertical section for evaluation of the incisal wall. The minimum wall thicknesses of pre- and post-preparation sections were observed at cervical level of proximal surfaces (1.25 mm and 0.42 mm, respectively). Murray et al. [22] showed that a RWT of 0.5 mm protects the pulp from injury. They also reported that maximum reactionary wall deposition occurred in a RWT of 0.25 to 0.5 mm [8] and that a RWT of 0.5 mm had a small effect on vitality of odontoblasts [9]. Zollner et al. [10] showed that RWT had a more profound effect on pulp injury than the type of tooth preparation, and maximum pulp reactions were reported in marginal pulp chamber area in RWT values of less than 2 mm. Pameijer et al. [24] reported that a RWT of 1 mm and Stanley et al. [23] showed that a RWT of 2 mm are essential for protecting the pulp. Our study showed that minimal RWT in proximal surfaces was less than 0.5 mm. Therefore, the possibility of pulp injury in mandibular incisors following all-ceramic crown preparations may be high. Valderhaug et al. [18] reported a low incidence of pulp injury in crowned teeth with vital pulps. Jackson et al. [16] reported that 5.7% of crowned vital teeth showed symptoms of irreversible pulpitis.

Some attentions including using plentiful water spray, non continuous preparation and less tapering wall are other important factors in preventing pulp injury. Jalalian and Aletaha [29] suggested more conservative preparation (0.7 mm) for zirconia crowns.

Conclusion

According to the results of the present study, the least amount of initial and remained wall thicknesses of pulp chamber were related to proximal surfaces, particularly in cervical areas. Therefore a reduction of preparation to 0.7 mm is suggested to prevent future pulp injury for mandibular incisors in 35 to 40-year-old patients and younger who require all-ceramic crown preparations.

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References

[1] Wylie SG, Tan HK, Brooke K. Restoring the vertical dimension of mandibular incisors with bonded ceramic restorations. Aust Dent J 2000; 45: 91-96.

[2] Walter RD, Raigrodski AJ. Critical appraisal: clinical considerations for restoring mandibular incisors with porcelain laminate veneers. J Esthet Restor Dent 2008; 20: 276-281.

[3] Ho HH, Chu FC, Stokes AN. Fracture behavior of human mandibular incisors following endodontic treatment and porcelain veneer restoration. Int J Prosthodont 2001; 14:

260-264.

[4] Schwartz NL, Whitsett LD, Berry TG, Stewart JL. Un serviceable crowns and fixed partial dentures: life-span and causes for loss of serviceability. J Am Dent Assoc 1970; 81: 1395-1401.

[5] Meeuwissen R, Eschen S. Prosthodontic treatment and retreatment of 845 servicemen. J Prosthet Dent 1985; 53: 425-427.

[6] Foster LV. Failed conventional bridge work from general dental practice: clinical aspects and treatment needs of 142 cases. Br Dent J 1990; 168: 199-201.

[7] Wisithphrom K, Murray PE, About I, Windsor LJ. Interactions between cavity preparation and restoration events and their effects on pulp vitality. Int J Periodontics Restorative Dent 2006; 26: 596-605.

[8] Murray PE, About I, Lumley PJ, Franquin JC, Remusat M, Smith AJ. Cavity remaining dentin thickness and pulpal activity. Am J Dent 2002; 15: 41-46.

[9] Murray PE, Lumley PJ, Hafez AA, Cox CF, Smith AJ. Preserving the vital pulp in operative dentistry: 4. Factors influencing successful pulp capping. Dent Update 2002; 29: 225-30, 232-233.

[10] Zöllner A, Gaengler P. Pulp reactions to different preparation techniques on teeth exhibiting periodontal disease. J Oral Rehabil 2000; 27: 93-102.

[11] Cheung GS, Lai SC, Ng RP. Fate of vital pulps beneath a metal-ceramic crown or a bridge retainer. Int Endod J 2005; 38: 521-530.

[12] Lockard MW. A retrospective study of pulpal response in vital adult teeth prepared for complete coverage restorations at ultrahigh speed using only air coolant. J Prosthet Dent 2002; 88: 473-478.

[13] Christensen GJ. Avoiding pulpal death during fixed prosthodontic procedures. J Am Dent Assoc 2002; 133: 1563-1564.

[14] Ericson S, Hedegård B, Wennström A. Roentgenographic study of vital abutment teeth. J Prosthet Dent 1966; 16: 981-987.

[15] Cheung GS. A preliminary investigation into the longevity and causes of failure of single unit extracoronal restorations. J Dent 1991; 19: 160-163.

[16] Jackson CR, Skidmore AE, Rice RT. Pulpal evaluation of teeth restored with fixed prostheses. J Prosthet Dent 1992; 67: 323-325.

[17] Palmqvist S, Swartz B. Artificial crowns and fixed partialdentures 18 to 23 years after placement. Int J Prosthodont 1993; 6: 279-285.

[18] Valderhaug J, Jokstad A, Ambjørnsen E, Norheim PW. Assessment of the periapical and clinical status of crowned teeth over 25 years. J Dent 1997; 25: 97-105.

[19] Saunders WP, Saunders EM. Prevalence of periradicular periodontitis associated with crowned teeth in an adult Scottish subpopulation. Br Dent J 1998; 185: 137-140.

[20] Murray PE, About I, Franquin JC, Remusat M, Smith AJ. Restorative pulpal and repair responses. J Am Dent Assoc 2001; 132: 482-491.

[21] About I, Murray PE, Franquin JC, Remusat M, Smith AJ. The effect of cavity restoration variables on odontoblast cell numbers and dental repair. J Dent 2001; 29: 109-117.

[22] Murray PE, Smith AJ, Windsor LJ, Mjör IA. Remaining dentine thickness and human pulp responses. Int Endod J 2003; 36: 33-43.

[23] Stanley HR. Dental iatrogenesis. Int Dent J 1994; 44: 3-18.

[24] Pameijer CH, Stanley HR, Ecker G. Biocompatibility of a glass ionomer luting agent. 2. Crown cementation. Am J Dent 1991; 4: 134-141.

[25] Christensen GJ. How to kill a tooth. J Am Dent Assoc 2005; 136: 1711-1713.

[26] Laforgia PD, Milano V, Morea C, Desiate A. Temperature change in the pulp chamber during complete crown preparation. J Prosthet Dent 1991; 65: 56-61.

[27] Rosenstiel SF Land MF, Fujimoto J. Contemporary Fixed Prosthodontics. 4th ed. St Louis: Mosby, Elsevier; 2006. p.326.

[28] Yapp R. Tooth preparation guidelines for zircunia crowns. Available at: http://www.dentaladvisor.com/publications/clinician technique-guide/tooth-preparation-guidelines-for- zirconia-crowns.pdf

[29] Jalalian E, Aletaha NS. The effect of two marginal designs (chamfer and shoulder) on the fracture resistance of all ceramic restorations, Inceram: an in vitro study. J Prosthodont Res 2011; 55: 121-125.