

# An *in Vitro* Analysis to Evaluate Coronal Residual Dentine Thickness after Different Anterior Crown Preparations

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## Abstract

**Background:** Knife edge, chamfer, and shoulder are the three distinct finishing lines utilized in crown preparations. Each finishing line has relative benefits and drawbacks. However, not much scientific data exists regarding which of these finishing lines will leave the most amount of residual dentine coronally on maxillary lateral incisors and mandibular incisors. **Objective:** To assess the coronal residual dentine thickness after different cervical finishing lines for anterior crown preparations. **Materials and Methods:** A prospective comparative study was conducted including mandibular incisors and maxillary laterals that were taken from subjects from 18 to 30 years old. Teeth in each of the three groups were randomly separated into three cervical margin preparation groups: knife edge, chamfer and shoulder. The teeth were then prepared for single crown coverage using these finishing lines. The teeth were sectioned halfway through the crown preparation, and a digital caliper was used to determine the residual dentine thickness at the buccal, lingual, mesial and distal areas. The Tukey test was used for mean comparison, and ANOVA analysis was used to evaluate the variation in mean residual dentine thickness. **Results:** For upper *lateral incisors*, knife edge finishing lines showed the highest amount of remaining dentine thickness—1.5 mm. lingually, while the *upper lateral incisors* mesially had the least amount of 0.53 mm for shoulder finishing lines. The least residual dentine (0.53 mm for the shoulder and 0.70 mm for the chamfer finishing line) was found in the interproximal portions of all the teeth that were selected. Lower central incisors had the least amount of residual dentine 0.61 mm for shoulder preparations mesially while lower

lateral incisors had the least amount of residual dentine for shoulder preparations 0.58 mm distally. There was a statistically significant difference of 0.001 across the groups. **Conclusion:** The thickness of residual dentine seen coronally after the three finishing line preparations showed a statistically significant difference and the knife edge finishing line provided enough coronal protection within the scope of this study.

## Keywords

Coronal, Finishing Lines, Residual Dentine Thickness

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## 1. Introduction

The residual dentine has been known to play a significant role in protecting the pulp after crown preparations as well as in cavity preparations. It has been well documented that a reduced amount of residual dentine has led to devitalization of the pulp following crown preparation because there is less protection from restorative chemicals, bacteria heat and restorative events. [1] [2] The mean thickness of residual dentine has been changing over the years. [3] Stanley *et al.* [4] and Chandler *et al.* [5] advocated for a residual dentine thickness of 2 mm while Pameijer *et al.* [6] noticed that a mean residual thickness of 1 mm was enough to protect the pulp from restorative chemicals like glass ionomer cement. Devitalization of the pulp was seen in their study to be inevitable when the residual dentine is less than 1 mm. [6] Borelli *et al.* [7] in their study measuring residual dentine thickness for lower central incisors, lower lateral incisors and lower canines demonstrated that lower central incisors with shoulder preparations can have a mean residual dentine thickness of 0.64 mm mesially which is lower than the recommended amount by Chandler *et al.* [5] and Pameijer *et al.* [6] Teeth with less residual dentine are also more susceptible to fracture and do not bond as strongly to luting cements because they have higher exudation of dentinal fluids and less intertubular dentine which bonds better to luting cements. [3]

Research has shown that when the residual dentine thickness is decreased during crown preparation, the pulp is more susceptible to serious damage caused by restorative events. [8] [9]. The smallest teeth in the arch like the central and lateral incisors of the mandible as well as the lateral incisors of the maxilla may require full coverage crowns for various reasons. The amount of residual dentine after preparation of these small crowns may be less than the well documented amount of 2 mm which is known to be protective of the pulp. [10]

Different finishing lines have been used in the provision of all ceramic crowns. Standard crown preparations have been well documented for the different finishing lines. After these reductions the residual dentine at the different sides of the tooth especially in the smallest teeth in the arch is not known.

This paper's goal was to use a digital caliper to measure the thickness of residual dentine of the coronal half of a crown prepared tooth on the mesial, distal, lingual, and buccal sides of the mandibular central and lateral incisors as well as the maxillary lateral incisors after tooth preparation with shoulder, chamfer, and knife edge finishing lines. Additionally, to assess the variations in dentine thickness that remain after tooth preparation on the mesial, distal, lingual, and buccal sides of the mandibular central and lateral incisors as well as the maxillary lateral incisors using finishing lines such as the knife edge, chamfer, and shoulder.

## 2. Materials and Methods

The Korle-Bu Teaching Hospital's institutional review board was consulted to obtain ethical permission. (IRB-KBTH/00026/2022) This prospective comparison study was conducted at the University of Ghana Dental School's Phantom head simulation laboratory from September 2, 2022, to November 5, 2022. 135 extracted teeth from the University of Ghana Dental School's tooth bank made up the study sample. The teeth belonged to adults between the ages of 18 and 30 and were whole adult teeth with fused apices and no fractures.

### 2.1. Data Collection

Using loops that magnified each tooth by 3.5 and a light source, the teeth were divided into the various tooth types namely mandibular central and lateral incisors and maxillary lateral incisors based on their morphology. Each type of tooth was then kept separately in Eppendorf bottles containing 10% formalin. Every tooth was X-rayed in both the buccolingual and mesiodistal directions, and only those teeth that met the inclusion requirements were kept. Using a simple sample technique, each tooth type was split into three groups at random to prepare the three cervical margin finishing kinds (shoulder, chamfer, and knife edge). A graphite pencil was used to label each tooth at the cemento-enamel junction. The graphite pencil was used by Bharathi *et al.* [11] in their study to mark bone during cranioplasty and they noticed that the markings were not washed away with body fluids and lasted till the end of the procedure. Using a digital caliper, the buccolingually and mesiodistally crown width 0.5 mm above the cervical margin, as well as the crown height buccolingually and mesiodistally from the cemento-enamel junction, were measured. With the use of a separating disc, two thirds of each tooth's root was sectioned off. This was done in order to shorten the tooth so that it would fit into the phantom head's socket and enable acrylic to be used in place of the root. Using silicone putty, silicone indexes were created. The first index was sectioned mesiodistally, and the second index was formed longitudinally along the tooth's long axis. The lingual and labial portions of a third index were created. This index's gingival and incisal halves made up its buccal half.

As indicated in **Table 1** below, the three separate tooth preparations were completed in accordance with the minimal standard preparation criteria.

**Table 1.** Displays the amount of tooth substance removed (mm) from the study sample at different locations.

	Tooth third Tooth area	Incisal	Middle			Cervical		
			Buccal	Interproximal	Lingual	Buccal	Interproximal	Lingual
	SHOULDER	1.5	1.5	1.2	1.5	1.2	1	1
FINISHING LINES	CHAMFER	1.5	1.2	1	1.2	0.8	0.6	0.6
	KNIFE EDGE	1.5	1.2	0.8	1.2	0.1	0.1	0.1

With the use of a digital caliper, University of North Carolina (UNC) probe, and silicone indexes, reductions were carried out and confirmed. After tooth preparation, the teeth were marked using a graphite marker halfway up the preparation. The teeth were sectioned perpendicularly to the long axis at the coronal level which had been marked. A 0.3 mm thin disc was used to minimize the amount of residual dentine lost during sectioning as has been done in various studies. [12] [13] The mesial (AMco), distal (ADco), lingual (ALco) and buccal (ABco) sides from the preparation surface to the surface of the pulp chamber was then measured.

## 2.2. Data Management and Analysis

For statistical analysis, the data was directly entered into an Excel work sheet, cleaned, and exported into SPSS version 25. The means and standard deviations were used to provide a descriptive summary of the remaining dentine thickness. The statistical significance of the difference in mean residual dentine thickness between the various finishing lines at each location in each tooth type was evaluated using a one-way analysis of variance (ANOVA). Pairwise mean comparison (means of any two groups) was performed using the Tukey test.  $P < 0.05$  was designated as the level of statistical significance.

## 3. Results

A total of 135 teeth were prepared, 45 of which were the mandibular lateral incisors, maxillary lateral incisors, and mandibular central incisors.

As shown in **Table 2** below the teeth were measured to get the thickness of enamel and dentine at the different areas of the upper lateral's, lower centrals, and lower laterals. The means for the enamel-dentine thickness for upper laterals mesially at the coronal section was 1.73 mm for teeth on which shoulder, chamfer and knife edge preparations were to be done. Distally at the coronal level the means for the enamel dentine thickness for upper laterals and lower centrals was 1.90 and 1.91 for shoulder and chamfer respectively and 1.95 mm for those on which knife edge was to be done. It showed that the mean values for the different types of teeth to be used for each tooth preparation was within a similar range.

**Table 3** below shows shoulder preparations had less residual dentine thickness compared to chamfer preparations at all four preparation areas for upper lateral teeth and lower centrals. Knife edge preparations had the most amount of

**Table 2.** Mean values (mm) and standard deviations (SDs) of computed enamel dentin thickness before preparations coronally.

Group	Mandibular teeth	Finish Line	Measurement			
			Computed mean enamel-dentine thickness before preparations (mm ± SD)			
			Mesial Mco	Distal Dco	Lingual Lco	Buccal Bco
1	Upper Laterals	Shoulder	1.73 ± 0.39	1.90 ± 0.13	2.80 ± 0.32	2.81 ± 0.34
2		Chamfer	1.73 ± 0.35	1.91 ± 0.22	2.66 ± 0.21	2.82 ± 0.30
3		Knife Edge	1.73 ± 0.19	1.95 ± 0.27	2.70 ± 0.30	2.71 ± 0.24
4	Lower Centrals	Shoulder	1.82 ± 0.11	1.83 ± 0.08	2.65 ± 0.25	2.51 ± 0.19
5		Chamfer	1.80 ± 0.17	1.97 ± 0.26	2.77 ± 0.12	2.57 ± 0.12
6		Knife Edge	1.82 ± 0.16	1.87 ± 0.19	2.78 ± 0.30	2.59 ± 0.20
7	Lower Laterals	Shoulder	1.87 ± 0.08	1.78 ± 0.20	2.71 ± 0.30	2.82 ± 0.32
8		Chamfer	1.80 ± 0.17	1.70 ± 0.10	2.75 ± 0.20	2.63 ± 0.22
9		Knife Edge	1.80 ± 0.24	1.85 ± 0.29	2.57 ± 0.36	2.67 ± 0.25

**Table 3.** Mean values (mm) and standard deviation (SDs) of residual dentin thickness after preparations coronally.

Group	Mandibular teeth	Finish Line	Mean residual dentine thickness after preparations coronally (mm ± SD)			
			Mesial (AMco)	Distal (ADco)	Lingual (Alco)	Buccal (ABco)
1	Upper Laterals	Shoulder	0.53 ± 0.39	0.70 ± 0.13	1.30 ± 0.33	1.32 ± 0.34
2		Chamfer	0.73 ± 0.36	0.92 ± 0.22	1.47 ± 0.21	1.62 ± 0.30
3		Knife Edge	0.93 ± 0.19	1.15 ± 0.27	1.50 ± 0.30	1.51 ± 0.24
4	Lower Centrals	Shoulder	0.61 ± 0.11	0.63 ± 0.08	1.15 ± 0.25	1.02 ± 0.18
5		Chamfer	0.80 ± 0.17	0.97 ± 0.26	1.57 ± 0.12	1.37 ± 0.12
6		Knife Edge	1.02 ± 0.16	1.07 ± 0.19	1.58 ± 0.30	1.39 ± 0.20
7	Lower Laterals	Shoulder	0.67 ± 0.08	0.58 ± 0.20	1.22 ± 0.30	1.32 ± 0.32
8		Chamfer	0.80 ± 0.17	0.70 ± 0.10	1.55 ± 0.98	1.43 ± 0.22
9		Knife Edge	1.00 ± 0.25	1.05 ± 0.29	1.37 ± 0.36	1.47 ± 0.25
P-value			0.001	0.001	0.001	0.001

residual dentin at all four sides for lower centrals. Statistically significant differences. Chamfer preparations showed more residual dentine thickness than shoulder and knife edge preparations with mean residual dentine thickness of 1.62 mm buccally for upper laterals, and lingually for lower laterals. The standard deviations remained relatively the same between the before and after preparations.

#### 4. Discussion

In this study, after preparations of upper lateral incisors, the knife edge finishing

line coronally showed the most amount of residual dentine mesially, distally, lingually and buccally. While shoulder preparations showed the least amount of residual dentine. The same trend was seen coronally in preparations for lower central and lower lateral teeth. Lower lateral teeth in this sub-region could be smaller due to racial dimorphism than what was seen in a Caucasian population as was seen in the study by Borelli *et al.* [7] Sheid *et al.* [14], in a study averaging measurements on 4572 extracted teeth obtained from patients who attended Ohio state university college of dentistry from 1974 to 1979 showed that there are disparities across races in the shape and size of some teeth. This can explain why after preparations for shoulder, chamfer and knife edge the thickness of residual dentine was smaller than the afore mentioned studies. Knife edge preparations in this study still had less than the 2 mm advocated for by Murray *et al.* [15] and Stanley *et al.* [6] which they suggested was the amount of residual dentine needed to fully protect the pulp. This study therefore indicates that for knife edge preparations since the amount of residual dentine mesially for upper lateral teeth at the coronal level is at 0.93 mm, Pulpal damage is most likely to start from the mesial section of upper lateral incisors with knife edge finishing lines coronally. Lower central and lower lateral teeth with knife edge preparations will be protected from the adverse effects of glass ionomer cements because the residual dentine thickness found on these teeth with knife edge preparations was more than the 1 mm thickness suggested by Pameijer *et al.* [6] In shoulder and chamfer preparations in upper lateral and lower central teeth in this study, the residual dentine thickness mesially was seen to be less compared to the other three sides. In lower lateral teeth however, the distal residual dentine thickness coronally was thinner than the mesial for shoulder and chamfer preparations.

Sheid *et al.* [14] found two shallow developmental depressions mesially on 48% of 793 mandibular central incisors, and on 51% of 787 mandibular lateral incisors, with that for lower central incisors slightly deeper.

The presence of these depressions in averagely about 50 percent of lower central and lateral incisors can be the reason why after preparations for all three finishing lines, lower central incisors had a reduced amount of residual dentine left at the mesial surfaces compared to the distal sides.

This indicates that the amount of enamel and dentine at the mesial sides of lower central incisors were less than the distal sides so if the same amount of enamel and dentine is removed during preparations the amount left at the mesial sides will be less than that at the distal end.

When the minimum recommended amounts of enamel and dentine were removed from the mesial sides of shoulder and chamfer preparations in upper lateral and lower central teeth the amount of residual dentine left was less than 1 mm for these two teeth.

This study therefore indicates that pulpal damage most likely will start from the mesial sides of upper lateral and lower central teeth with shoulder and chamfer preparations coronally but will start at the distal parts of lower lateral teeth in teeth prepared with these same finishing lines coronally. The SPSS anal-

ysis for the mesial, distal, lingual and buccal after the preparation coronally showed a statistically significant difference across the mesial, distal, buccal preparations but had a statistically insignificant difference against the lingual preparations. This was similar to that seen in the study by Borelli *et al.* [7] The pairwise Tukey's analysis showed that all the different sides of each preparation type had a statistically significant difference against all the other preparation types.

## 5. Conclusions

It was evident that the finishing line, knife edge was more conservative of tooth structure coronally.

Even though knife edge preparations showed the most amount of residual dentine thickness on all sides of the preparations compared to shoulder and chamfer preparations the least amount of residual dentine was seen at the mesial sides of these knife edge preparations for all three types of teeth coronally.

The mesial sides of upper lateral incisors were therefore seen to be critical in knife edge preparations as potentially the structural and biologic integrity of these teeth can potentially be interfered with from this side. Knife edge preparations on lower lateral incisors and lower central incisors were seen to be protective of the pulp because the amount of residual dentine found on all sides of the teeth coronally was more than 1 mm.

## 6. Limitations

Chromatic and anatomical variations in teeth could bring about errors.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

- [1] Langeland, K. and Langeland, L.K. (1970) Pulp Reactions to Cavity and Crown Preparation. *Australian Dental Journal*, **15**, 261-276. <https://doi.org/10.1111/j.1834-7819.1970.tb03389.x>
- [2] Bergenholtz, G., Cox, C.F., Loesche, W.J. and Syed, S.A. (1982) Bacterial Leakage around Dental Restorations: Its Effect on the Dental Pulp. *Journal of Oral Pathology & Medicine*, **11**, 439-450. <https://doi.org/10.1111/j.1600-0714.1982.tb00188.x>
- [3] Seyedasharafali, S., Karthigeyan, S., Madhan, R. and Krishnaraj, R. (2016) Evaluation of Remaining Dentin Thickness (RDT) Following Tooth Preparation for All Ceramic Crowns—An *in Vitro* Study. *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, **15**, 66-70. <https://doi.org/10.9790/0853-1510036670>
- [4] Stanley, H.R. (1993) Pulpal Responses to Conditioning and Bonding Agents. *Journal of Esthetic and Restorative Dentistry*, **5**, 208-214. <https://doi.org/10.1111/j.1708-8240.1993.tb00782.x>
- [5] Chandler, N.P., Pitt Ford, T.R. and Monteith, B.D. (2003) Coronal Pulp Size in Molars: A Study of Bitewing Radiographs. *International Endodontic Journal*, **36**, 757-763. <https://doi.org/10.1046/j.1365-2591.2003.00726.x>

- [6] Pameijer, C.H., Stanley, H.R. and Ecker, G. (1991) Biocompatibility of a Glass Ionomer Luting Agent. 2. Crown Cementation. *American Journal of Dentistry*, **4**, 134-141.
- [7] Borelli, B., *et al.* (2015) Evaluating Residual Dentin Thickness Following Various Mandibular Anterior Tooth Preparations for Zirconia Full-Coverage Single Crowns: An *In Vitro* Analysis. *International Journal of Periodontics and Restorative Dentistry*, **35**, 41-47. <https://doi.org/10.11607/prd.1873>
- [8] Santini, A. and Ivanovic, V. (1996) The Quantification of Tertiary Dentine Formation in Response to Materials Commonly Placed in Deep Cavities in General Practice in the UK. *Primary Dental Care*, **3**, 14-22.
- [9] Weiner, S. and Zaslansky, P. (2004) Teeth: Structure/Mechanical Design Strategies. *Encyclopedia of Materials: Science and Technology*, 1-5  
<https://doi.org/10.1016/B0-08-043152-6/01919-7>
- [10] Stanley, H.R. (1994) Dental Iatrogenesis. *Dentistry Today*, **13**, 3-18.
- [11] Mohan, P.B., *et al.* (2020) Innovative Use of Graphite Pencil in Cranioplasty. *World Journal of Plastic Surgery*, **9**, 104-105.
- [12] Smith, R.N., Brook, A.H. and Karmo, M. (2009) The Relationship Between the Mid-Point and Most-Prominent Point on the Labial Curve of Upper Anterior Teeth. *The Open Dentistry Journal*, **3**, 167-172.  
<https://doi.org/10.2174/1874210600903010167>
- [13] Gjørup, H., *et al.* (2009) Hypocalcified Type of Amelogenesis Imperfecta in a Large Family: Clinical, Radiographic, and Histological Findings, Associated Dento-Facial Anomalies, and Resulting Treatment Load. *Acta Odontologica Scandinavica*, **67**, 240-247. <https://doi.org/10.1080/00016350902973685>
- [14] Sheid, R.C. and Weiss, G. (2012) Woelfel's Dental Anatomy. 8th Edition, Jones & Bartlett Learning, Massachusetts.
- [15] Murray, P.E., Smith, A.J., Windsor, L.J. and Mjör, I.A. (2003) Remaining Dentine Thickness and Human Pulp Responses. *International Endodontic Journal*, **36**, 33-43. <https://doi.org/10.1046/j.0143-2885.2003.00609.x>