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RESEARCH ARTICLE

An in vitro comparative study of the marginal fit of six types of cervical finish lines

Estudio comparativo in vitro del ajuste marginal de seis tipos de límites cervicales

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Abstract

Introduction: The design of tooth-supported fixed prostheses includes basic elements such as the cervical finish line, which represents the zone of the junction between the prepared tooth structures and the margin of a restorative material. The choice of the type of finish line is determined by several factors, therefore, the design of the cervical finish line determines the form and the tooth reduction, that is carried out in the marginal area.

Objective: To determine which cervical termination design achieves the lowest marginal fit.

Methods: A preliminary in vitro comparative study, using a convenience sampling, was carried out. Forty-eight complete peripheral preparations were carved from rolled steel cylinders. Then, the samples were divided into six groups, according to their finish line: knife edge, chamfer, straight shoulder, 45º beveled straight shoulder, 85º beveled straight shoulder, and sloped shoulder. Each group of samples with their cemented caps was embedded in transparent, self-polymerizing acrylic. The samples were sectioned axially and examined with a scanning electron microscope.

Results: The finish lines with the lowest absolute marginal discrepancy were the 45º beveled straight shoulder (54.3 µm ± 16.3), the sloped shoulder (73.6 µm ± 26.1), and the chamfer (76.1 µm ± 39.0).

Conclusions: There was no statistically significant difference among the three terminations with the lowest absolute marginal discrepancy. The 45° beveled straight shoulder was the cervical finish line with the best mean marginal fit, but the smallest absolute marginal discrepancy occurred at the chamfer.

Keywords: Dental marginal adaptation; dental crowns; tooth preparation; dental prosthesis; Chile.

Resumen

Introducción: El diseño de prótesis fijas dentosoportadas incluye elementos básicos como la terminación cervical, que representa la zona de unión entre las estructuras dentales preparadas y el margen de un material restaurador. La elección del tipo de línea de terminación está determinada por varios factores, por lo tanto, el diseño de la línea de terminación cervical determina la forma y cantidad de reducción dentaria que se realiza en la zona marginal.

Objetivo: Determinar el diseño de terminación cervical que logra el menor ajuste marginal.

Métodos: Se realizó un estudio comparativo preliminar in vitro, mediante muestreo por conveniencia. Se tallaron 48 preparaciones periféricas completas a partir de cilindros de acero laminado. Posteriormente, se distribuyeron en seis grupos según su línea de terminación: filo de cuchillo, chamfer, hombro recto, hombro recto biselado a 45º, hombro recto biselado a 85º y hombro inclinado. Cada grupo con sus casquetes cementados se embebió en acrílico autopolimerizable. Las muestras se seccionaron axialmente y se observaron en un microscopio electrónico de barrido.

Resultados: Las líneas de terminación que presentaron la menor discrepancia marginal absoluta fueron el hombro recto biselado de 45° (54,3 µm ± 16,3), la terminación del hombro inclinado (73,6 µm ± 26,1) y el chamfer (76,1 µm ± 39,0).

Conclusiones: No existió diferencia estadísticamente significativa entre las tres terminaciones con menor discrepancia marginal absoluta. El hombro recto biselado a 45° fue la línea de terminación cervical con el mejor ajuste marginal medio, pero la discrepancia marginal absoluta más pequeña ocurrió en el chamfer.

Palabras clave: Adaptación marginal dental; coronas dentales; preparación del diente; prótesis dental; Chile.

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Introduction

The design of tooth-supported fixed prostheses includes basic elements, such as the finish line, which represents the junction between the prepared and unprepared tooth structures and the margin of restorative material.[1,2]

The type of finish line selected depends on several factors, including tooth position in the arch, aesthetic requirements, periodontal phenotype, caries presence, oral hygiene capability, crown volume, and restorative material used. These factors can significantly impact the marginal fit.[1,3,4,5] The correct evaluation of a marginal design requires consideration of multiple parameters, including the extent of tooth preparation, clearly defined limits, adequate space for the restorative materials, and protection of the remaining biological tissues. Consequently, the design of the cervical finish line significantly influences the morphology and volume (depth and extent) of tooth reduction in the marginal area, ensuring adherence to established compliance standards.[6,7]

Marginal fit, which is defined as the minimum distance from the tooth-restoration interface, is of vital importance for the long-term success of treatment. This is because the junction area is a potential site of caries recurrence and damage to the periodontal support tissue.[8,9,10] Rough and irregular junctions cause greater retention of bacterial plaque and make it more difficult to achieve a correct restoration adaptation. In some cases, they can even lead to occlusal disharmony or pulp pathology.[11]

The configuration of margins has been the subject of numerous analyses and debates. Although various designs have been proposed, there is no universally accepted standard for their classification. Additionally, many books and articles provide vague descriptions, rendering them indistinguishable from one another.[8]

The literature describes various marginal designs, such as straight shoulder, beveled straight shoulder (at 45°, 60°, 70°, or 85°), sloped shoulder at 135°, chamfer, deep beveled chamfer, and knife edge, among others. The way the tooth preparation is cut can influence the degree of approximation achieved between the restoration and the biological preparation. Several articles have analyzed the degree of marginal fit of single crowns with different finishes.[5,7,10,11,12,13]

Ahmed et al.[6] concluded from a review of 637 articles that zirconia crowns with shoulder finish exhibited better marginal adaptation than those with a chamfer finish. Furthemore, Yu et al.[7] and Rizonaki et al.[10] reported that ceramic crowns with a rounded shoulder finish exhibited significantly better marginal adaptation than those with a chamfer. However, Faruqi et al.[11] digitally evaluated the marginal adaptation of different types of all-ceramic crowns with shoulder and chamfer finishes and found that crowns with chamfer finish lines fit better (, had less marginal gap) than the shoulder finish lines across all groups.

There is currently no consensus on the most suitable finish line design for achieving an optimal marginal fit and internal adaptation.

The objective of this study was to determine which finish line design achieves the optimal and lowest marginal fit.

Methods

This preliminary in vitro comparative study used convenience sampling to perform 48 complete peripheral preparations from rolled steel cylinders (18 mm high and 8 mm in diameter), which were distributed into six groups according to their finish line: knife edge (a), chamfer (b), straight shoulder (c), 45° beveled straight shoulder (d), 85° beveled straight shoulder (e) and sloped shoulder (f). (fig. 1)

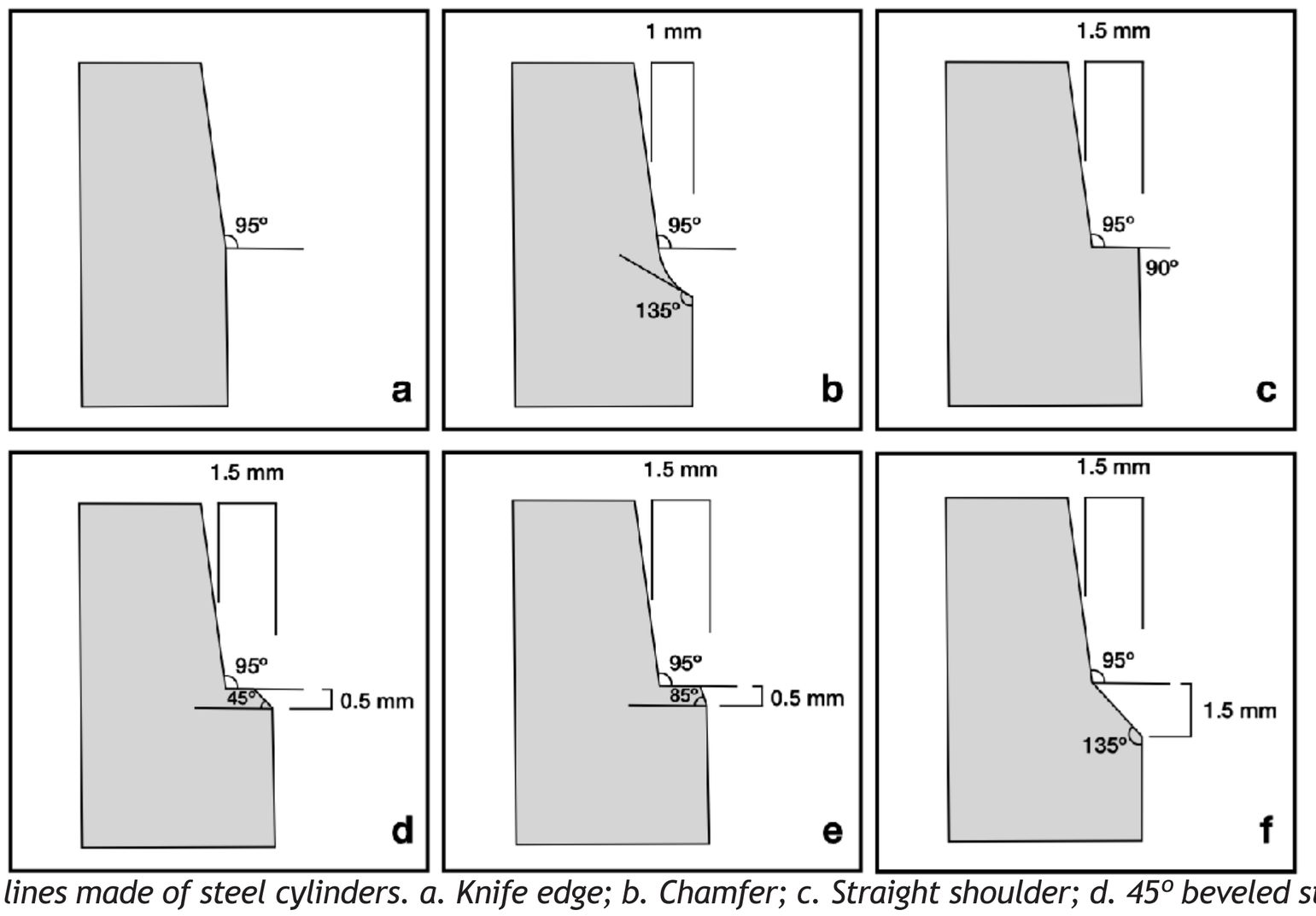


Fig. 1 - Finish lines made of steel cylinders. a. Knife edge; b. Chamfer; c. Straight shoulder; d. 45° beveled straight shoulder; e. 85° beveled straight shoulder; f. Sloped shoulder

These preparations were 8 mm high, measured from the cervical limit of the finish line to the occlusal surface of the preparation, leaving a 10 mm base. Additionally, the samples had a 10º convergence towards the occlusal. The preparations were carved on a mechanical lathe in the Department of Mechanical Engineering at the University of Chile's Faculty of Engineering.

The 48 samples were mounted and aligned on a self-curing acrylic base (Marché®, Chile) (fig. 2). Prior to taking the impression, each sample was held in its base area to index the future caps and allow them to be cemented in the same position as they would be made. The impression was made with polyvinyl siloxane and an aluminum tray 5 cm wide and 3 cm deep, perforated at various points on its base to achieve retention of the heavy and light addition silicone (Detaseal K, DETAX GmbH & Co. KG, Germany) (fig. 2).

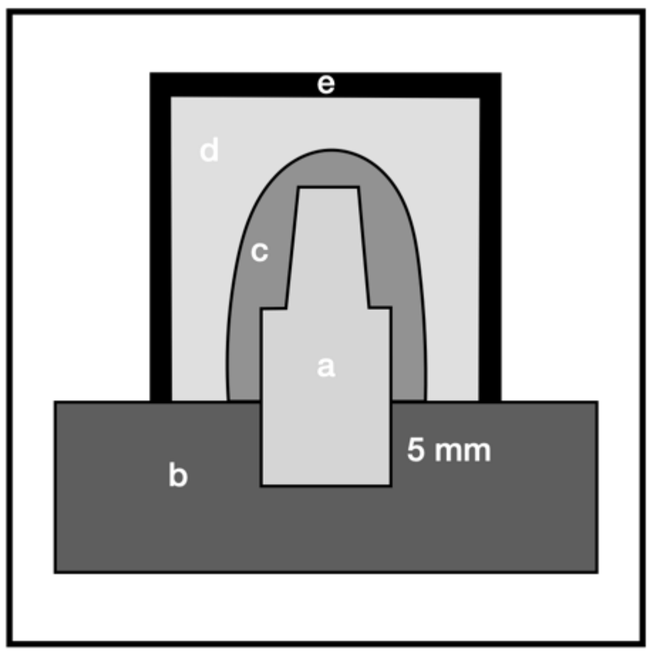


***Fig. 2** - Impression of metallic sample. (a) Sample; (b) acrylic base; (c) light silicone; (d) heavy silicone; (e) tray*

After taking the impressions, the extra-hard stone (Begostone®, Bego, Germany) was mixed under vacuum for one minute and then cast. The caps were made using the lost wax technique. After obtaining the casts (Wiron 77®, Bego, Germany) and evaluating possible defects, they were cemented to their respective samples with type I zinc phosphate cement (Goldsmith®, USA). Digital pressure was applied for 10 minutes, and then the excess cement was removed. Each group of samples with their cemented caps was then embedded in transparent self-polymerizing acrylic (Marché®, Chile). These groups of samples were then sectioned axially.

Excess acrylic was removed from each section to obtain quadrangular samples measuring 18 x 18 mm and 5 mm in thickness. These samples were observed using a scanning electron microscope (Digital Scanning Microscope DSM940, ZEISS®, Germany) from the Electron Microscopy Unit of the Morphology Program at the Institute of Biomedical Sciences, at the University of Chile's North School of Medicine. The objective was to measure the absolute marginal discrepancy of each sample with a magnification of 200X (figs. 3 and 4).

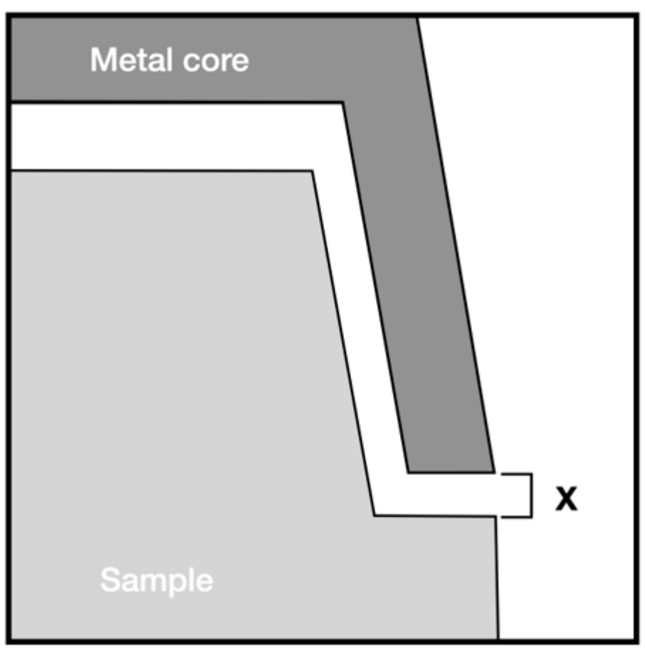


***Fig. 3** – Measurement of absolute marginal discrepancy*

Study variables

Finish line: Type of cervical termination, such as knife edge, chamfer, straight shoulder, 45º beveled straight shoulder, 85º beveled straight shoulder and sloped shoulder.

Absolute marginal discrepancy: Distance (in µm) between the preparation and the edge of the metal core.

Statistical analysis

The normality of the groups was determined using the Shapiro-Wilk test. A one-way analysis of variance (ANOVA) was performed to statistically evaluate the differences between the groups. Bonferroni post-estimation comparisons were made between the different groups.

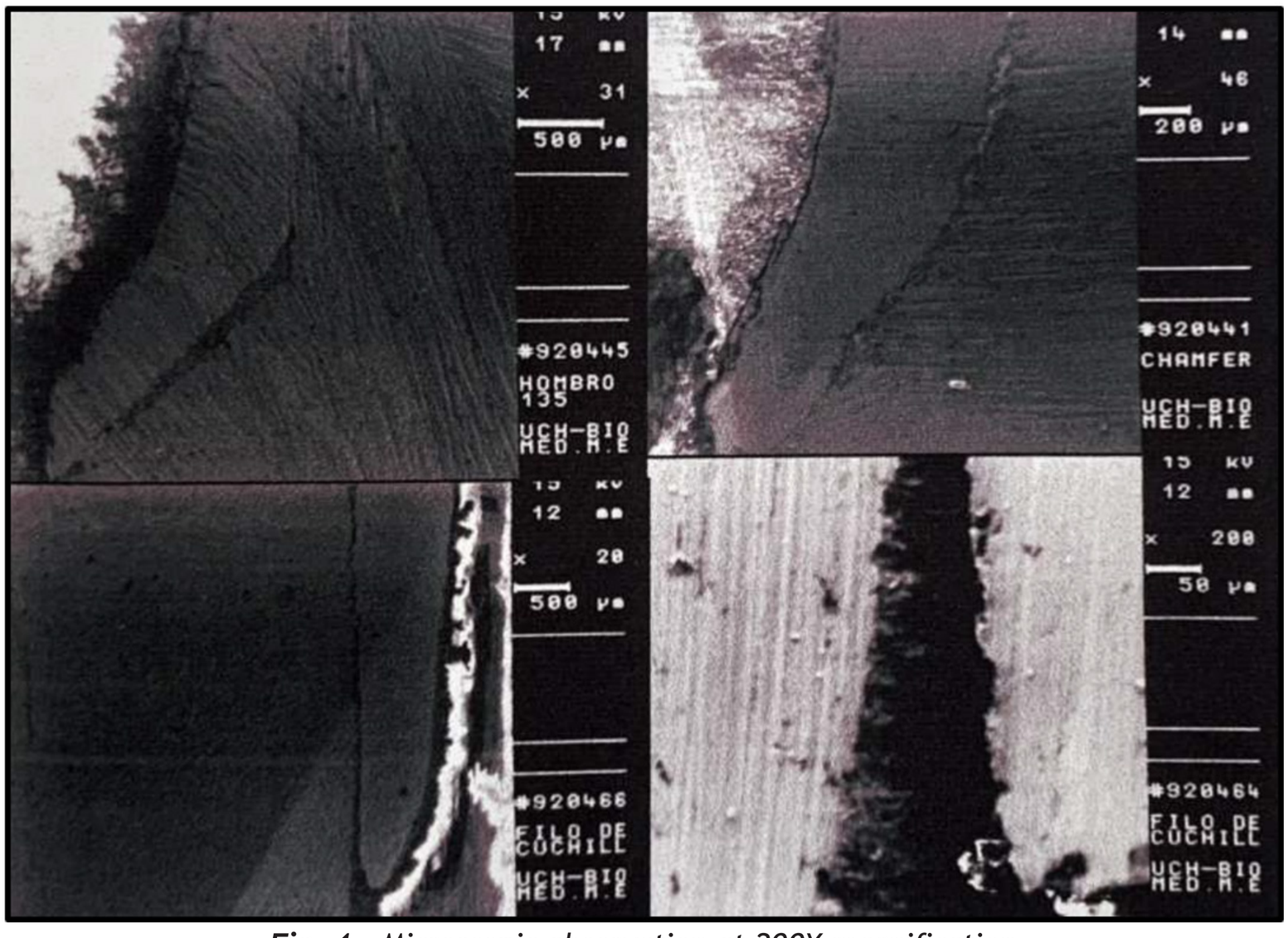


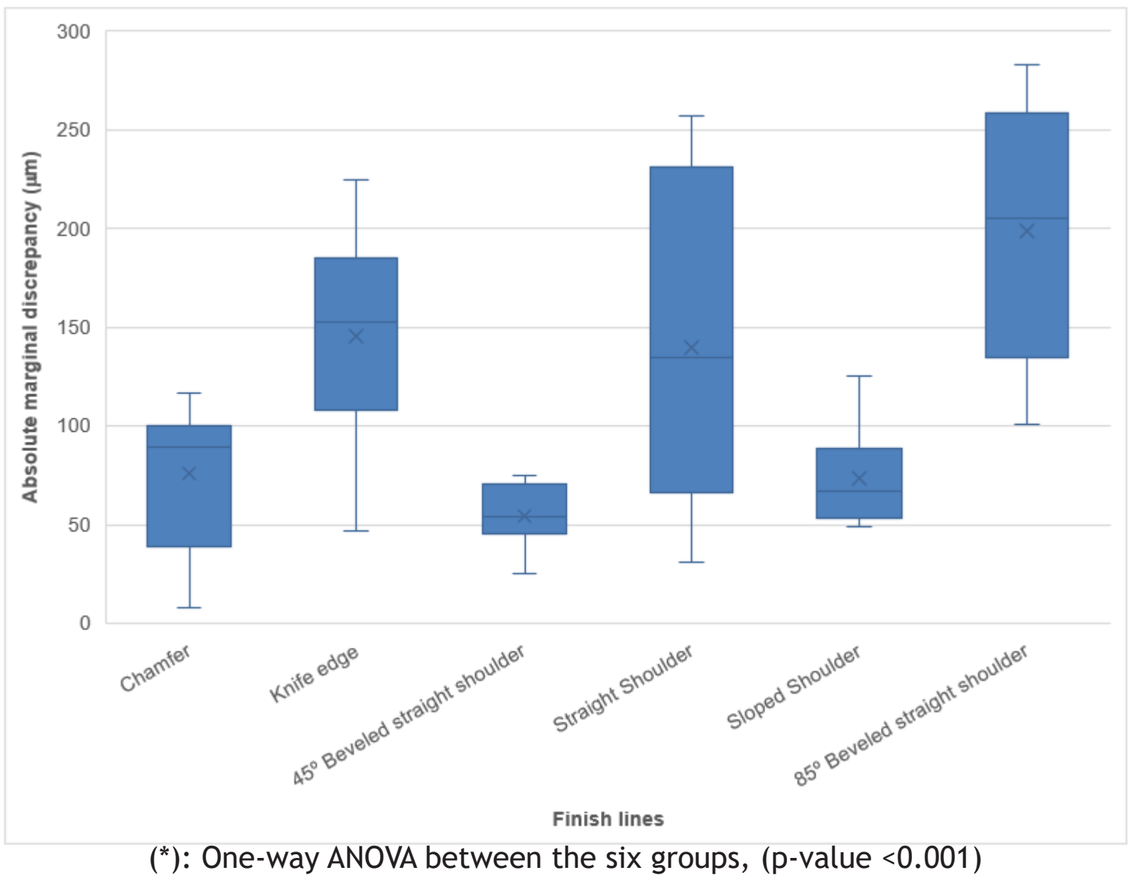
Fig. 4 - Microscopic observation at 200X magnification

Results

The finish lines with the lowest absolute marginal discrepancy were the 45º beveled straight shoulder (54.3 µm ± 16.3), the sloped shoulder (73.6 µm ± 26.1), and the chamfer (76.1 µm ± 39.0). The finish line with the greatest mean discrepancy was the 85º beveled straight shoulder (198.8 µm ± 64.6). The greatest dispersion was obtained in the straight shoulder finish line (minimum: 30.8 µm – maximum: 257.0 µm), and the lowest dispersion was obtained in the 45º beveled straight shoulder finish (minimum: 25.2 µm – maximum: 75.0 µm). Table 1 and fig. 5 show the descriptive results of the absolute marginal discrepancy for each group.

***Table 1** - Absolute marginal discrepancy values for each sample*

Finish line	Absolute marginal discrepancy (µm)	Finish line	Absolute marginal discrepancy (µm)
Chamfer	22.7	Knife edge	157.0
	117.0		165.3
	8.0		192.0
	86.0		47.0
	95.0		225.0
	88.0		101.2
	102.0		129.0
	90.0		148.0
Mean	76.1 ± 39.0	Mean	145.6 ± 54.7
45º Beveled straight shoulder	25.2	Straight shoulder	58.4
	44.3		127.0
	50.9		89.9
	49.3		155.0
	75.0		142.0
	58.0		257.0
	56.6		30.8
	75		138.0
Mean	54.3 ± 16.3	Mean	124.8 ± 69.0
Sloped shoulder	82.4	85º Beveled straight shoulder	223.0
	48.7		270.0
	55.0		212.0
	56.0		118.0
	78.0		198.7
	125.0		283.0
	52.3		185.0
	91.0		101
Mean	73.6 ± 26.1	Mean	198.8 ± 64.6



(*): One-way ANOVA between the six groups, (p-value <0.001)
One-way ANOVA between the three finish lines with the best fit (Chamfer, 45° beveled straight shoulder and sloped shoulder: (p-value >0.05)

***Fig. 5** - Average marginal fit values (absolute marginal discrepancy)*

Bonferroni post-estimation tests were applied. P-values less than 0.05 were detected between the following: 85° beveled straight shoulder and (chamfer - 45° beveled straight shoulder - sloped shoulder), and between knife edge and 45° beveled straight shoulder. The differences between groups are shown in Table 2.

Based on these results, the most important clinical finding was that the smallest absolute marginal discrepancy occurred in the chamfer. It is also easier to prepare clinically.

***Table 2** - Comparative p-values from ANOVA post-estimation analysis (Bonferroni)*

Comparison	Chamfer	45° Beveled straight shoulder	Sloped shoulder	Knife edge	Straight shoulder
45° Beveled straight shoulder	1.000				
Sloped shoulder	1.000	1.000			
Knife edge	0.105	0.009	0.080		
Straight shoulder	0.801	0.094	0.639	1.000	
85° Beveled straight shoulder	0.000	0.000	0.000	0.529	0.063

According to the ANOVA test, assuming there were statistically significant differences between the groups, the value of p <0.001 was explained by the great variability or dispersion in the results for the 85° beveled straight shoulder.

Discussion

This in vitro study analyzed the influence of different cervical termination line designs (chamfer, knife edge, straight shoulder, 45° beveled straight shoulder, 85° beveled straight shoulder, and sloped shoulder) on the degree of adaptation or marginal fit of complete peripheral metal caps cemented in their respective preparations.

Statistically significant differences were observed in the dispersion of data among all groups (ANOVA p-value <0.001). However, there was no statistically significant difference in the mean values of the absolute marginal discrepancy between the chamfer, 45° beveled straight shoulder, and sloped shoulder.

This finding is supported by previous studies. For example, the in vitro study by Subasi et al.[14] investigated the marginal fit of two all-ceramic copings with two finish line designs and revealed no statistically significant differences in marginal fit between the chamfer and rounded shoulder. Similarly, Akbar et al.[15] and Baig et al.[16] found no statistically significant difference when comparing chamfer and shoulder groups. However, the study by Risonaki et al.[10] showed that the marginal gap values were statistically significantly different between groups. In ascending order, the marginal gap values were 23 ± 14 µm for a rounded shoulder, 54 ± 28 µm for

a chamfer, and 96 ± 36 µm for a knife edge finish lines. A similar finding was reported in a study by Gunel et al.[17], which found that a crown preparation with a chamfer finish line showed a statistical difference with the lowest marginal discrepancy in comparison to a shoulder finish line.

For this study, the most important clinical finding was that the smallest absolute marginal discrepancy occurred at the chamfer, although the finish line with the smallest average absolute marginal discrepancy was the 45° beveled straight shoulder.

One of the main limitations of this study was that small samples may contain representativeness errors. Therefore, increasing the sample size by a smaller number of preparations will improve the statistical power of the results. The same applies to the number of preparations. Since this is a preliminary study, we can address these limitations with the intention of conducting future studies with larger samples and fewer preparations.

Future research should include a greater number of samples for each group to achieve a more representative sample size.

The importance of further research into the types of finishing lines is to determine their associated indications for the clinical success of crowns fabricated through digital or analog workflows.

Conclusions

The 45° beveled straight shoulder had the lowest mean marginal fit, followed by the sloped shoulder and the chamfer. There were no statistically significant differences between these three finishes. However, the smallest absolute marginal discrepancy occurred at the chamfer.

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Conflict of interest

Alain Manuel Chaple Gil is a member of the Editorial Committee of the Revista Cubana de Estomatología. The other authors declare that they have no conflicts of interest.

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