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ORIGINAL RESEARCH

Morphological Types and Dimensions of the Cervical Line in Maxillary Premolars: A Morphometric Study in the Chongjin Population

Hong, Gwang-Hyon[1]; Yu, Hong-Jin[1]; Pak, Myong-Chol[1]; Pak, Hong-Jin[1]; Kim, Yong-Ho[1]*

[1] *Faculty of Dentistry, Chongjin College of Medical Science, Chongjin, DPR Korea*

**Corresponding author: yhj1991127@163.com*

KEYWORDS

Cervical line; Cementoenamel junction; Maxillary premolars; Morphometry.

ABSTRACT

This study investigated cervical line type prevalence and dimensions in 670 maxillary premolars (296 first, 374 second). Cervical line morphology on the buccal, lingual, mesial, and distal surfaces was classified as straight or curved; curved lines were subdivided into type 1 (curvature height < 1/4 of the linear distance between endpoints) and type 2 (≥ 1/4 and < 1/2). Cervical width and thickness were measured. Intra-examiner reliability was assessed on 30 random teeth after 2 weeks. Chi-square or Fisher exact tests compared categorical variables; independent t tests compared continuous variables. In first premolars, the buccal surface was straight in 52.71%, curved type 1 in 43.92%, and curved type 2 in 3.37%; the lingual surface was predominantly straight (64.19%). Mesial and distal surfaces were predominantly curved (97.97% and 90.20%), mostly type 1 (93.24% and 88.85%). Second premolars showed similar trends, with curved type 2 absent buccally and rare lingually (0.53%). Cervical width was 4.9 ± 0.02 mm and 4.8 ± 0.02 mm, and thickness 8.1 ± 0.05 mm and 8.0 ± 0.03 mm, in first and second premolars, respectively. Sex differences were not significant on buccal, lingual, or distal surfaces ($P > 0.05$); mesial differences (Fisher $P = 0.030$ for both premolars) were driven by sparse straight-type cells. Cervical width was slightly larger in first premolars ($P = 0.0004$). Cervical line morphology varies considerably by tooth type and surface. Given sparse cells and small effect sizes, clinical relevance should be interpreted conservatively. These data inform clinical procedures involving the cervical region.

1. INTRODUCTION

The cementoenamel junction (CEJ), also known as the cervical line, represents the anatomical boundary between the enamel of the crown and the cementum of the root [1]. It serves as a critical landmark in clinical dentistry, particularly for the measurement of clinical attachment level (CAL) in periodontal diagnosis [2], and as a reference point for various restorative and endodontic procedures [3]. The CEJ is a fragile region, approximately 40–60 μm in width, which makes it susceptible to pathological changes and iatrogenic damage during clinical procedures [4].

The tissue interrelationships at the CEJ have been classified into four types: cementum overlapping enamel, enamel overlapping cementum, edge-to-edge relationship, and the presence of a gap with exposed dentin [1,4,5]. Subsequent studies have reported varying prevalence rates for these types depending on population, tooth type, and methodological approach [6–10]. However, most studies have focused on the tissue interrelationship at the CEJ rather than the macroscopic morphology of the cervical line itself.

The curvature of the cervical line is known to vary considerably among different tooth types and surfaces. In general, proximal surfaces exhibit greater curvature than buccal or lingual surfaces, and the mesial surface typically shows more pronounced curvature than the distal surface [4]. These morphological characteristics have significant clinical implications. For instance, the curvature of the cervical line affects the adaptation of matrix bands during restorative procedures, the placement of clamps during rubber dam isolation, and the measurement of CAL during periodontal examination [11-14].

Maxillary premolars are among the most frequently treated teeth in endodontic and restorative dentistry. They exhibit considerable anatomical variability, including variations in root number, root canal morphology, and external root features [15]. However, despite the clinical importance of the cervical region, detailed morphometric data on the cervical line of

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maxillary premolars remain limited. Most previous studies have focused on root canal morphology rather than the cervical line itself [16–25].

The aim of this study was to investigate the type prevalence and size of the cervical line in maxillary premolars, and to provide comprehensive morphometric data that can be applied in clinical practice. The specific objectives were: (1) to classify the morphology of the cervical line on four surfaces (buccal, lingual, mesial, and distal) of maxillary first and second premolars; (2) to measure the width and thickness of the cervical region; and (3) to analyze differences by sex and tooth type.

2. METHODOLOGY

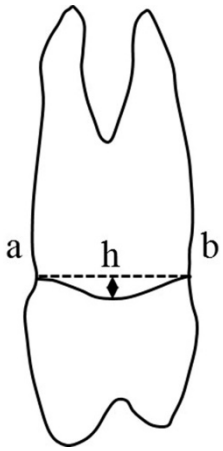
Sample

A total of 670 maxillary premolars (296 first premolars: 142 male and 154 female; 374 second premolars: 186 male and 188 female) were selected from a collection of extracted permanent teeth from patients who underwent tooth extraction at the Faculty of Dentistry, Chongjin College of Medical Science, Chongjin, DPR Korea, between February 2024 and March 2026. The age of the patients ranged from 19 to 25 years (23.37 ± 0.85 years). Teeth with caries, restorations, fractures, or developmental anomalies were excluded. All teeth had fully formed roots and intact cervical regions. This was an ex vivo morphometric study using extracted teeth. The study was reviewed and granted an exemption by the Institutional Review Board of Chongjin College of Medical Science (exemption no. 20240118).

Morphological Classification of the Cervical Line

The morphology of the cervical line was observed macroscopically according to previously established methods [15,16]. The cervical line was classified into two main types: straight type and curved type. The curved type was further subdivided into two subtypes based on the degree of curvature, as illustrated in Figure 1.

Figure 1. Schematic illustration of the cervical line curvature measurement. Points a and b represent the two endpoints of the cervical line; h represents the curvature height (the perpendicular distance from the most curved point to the line ab). The curvature type was determined by the ratio of h to ab: type 1 ($h < ab/4$) and type 2 ($ab/4 \leq h < ab/2$).



The curvature height (h) was defined as the perpendicular distance from the most curved point of the cervical line to the straight line connecting the two endpoints (a and b). The linear distance between the two endpoints was defined as ab. The curvature type was determined by the ratio of h to ab:

Type 1: $h < ab/4$

Type 2: $ab/4 \leq h < ab/2$

If the cervical line was straight, it was classified as straight type. Observations were made on four surfaces: buccal, lingual, mesial, and distal.

Measurement of Cervical Dimensions

The width and thickness of the cervical region were measured using a digital caliper (Mitutoyo CD-15CPX; Mitutoyo, Kawasaki, Japan; resolution 0.01 mm). The width was defined as the mesiodistal dimension at the level of the cervical line, and the thickness was defined as the buccolingual dimension at the same level. All measurements were performed three times by a single examiner, and the mean value was used for analysis. Before the main study, the examiner was calibrated on 20 randomly selected teeth. Intra-examiner reliability was assessed in 30 randomly selected teeth after a 2-week interval. Cohen's

kappa was used for categorical classification, and the intraclass correlation coefficient (ICC) was used for continuous measurements.

Statistical Analysis

Data were expressed as mean ± standard error (M ± SE) for continuous variables and as frequencies and percentages for categorical variables. Sex and tooth-type differences in categorical cervical line types were tested using the chi-square test; the Fisher exact test was used when expected counts were < 5. Continuous dimensions were compared using independent-samples t tests. Because the same teeth contributed to multiple surfaces, comparisons among the four surfaces were presented descriptively rather than tested as independent groups. A P value < 0.05 was considered statistically significant. Analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

3. RESULTS

Type Prevalence of the Cervical Line

Buccal Surface

In maxillary first premolars, the straight type was observed in 156 teeth (52.71%), curved type 1 in 130 teeth (43.92%), and curved type 2 in 10 teeth (3.37%). The total prevalence of curved type was 47.29%. In maxillary second premolars, the straight type was observed in 212 teeth (56.68%), curved type 1 in 162 teeth (43.32%), and curved type 2 was not observed. The total prevalence of curved type was 43.32% (Table 1). Sex differences in the distribution of straight versus curved types were not significant (first premolars: $\chi^2 = 0.254$, P = 0.615; second premolars: $\chi^2 = 0.287$, P = 0.592). The distribution did not differ significantly between first and second premolars ($\chi^2 = 1.058$, P = 0.304).

Tooth	Sex	N	Straight (%)	Curved		
				Type 1 (%)	Type 2 (%)	Total (%)
1st premolar	Male	142	77 (54.23)	61 (42.96)	4 (2.81)	65 (45.77)
	Female	154	79 (51.30)	69 (44.81)	6 (3.89)	75 (48.70)
	Total	296	156 (52.71)	130 (43.92)	10 (3.37)	140 (47.29)
2nd premolar	Male	186	108 (58.06)	78 (41.94)	0 (0)	78 (41.94)
	Female	188	104 (55.32)	84 (44.68)	0 (0)	84 (44.68)
	Total	374	212 (56.68)	162 (43.32)	0 (0)	162 (43.32)

Table 1. Type prevalence of the cervical line on the buccal surface of maxillary premolars. P for sex (straight vs curved): first premolars 0.615; second premolars 0.592. P for tooth type: 0.304.

Lingual Surface

In maxillary first premolars, the straight type was observed in 190 teeth (64.19%), curved type 1 in 104 teeth (35.14%), and curved type 2 in 2 teeth (0.67%). The total prevalence of curved type was 35.81%. In maxillary second premolars, the straight type was observed in 254 teeth (67.91%), curved type 1 in 118 teeth (31.55%), and curved type 2 in 2 teeth (0.53%). The total prevalence of curved type was 120 teeth (32.09%) (Table 2). Sex differences were not significant (first premolars: $\chi^2 = 1.562$, P = 0.211; second premolars: $\chi^2 = 0.005$, P = 0.943). The tooth-type comparison was also not significant (P = 0.311).

Tooth	Sex	N	Straight (%)	Curved		
				Type 1 (%)	Type 2 (%)	Total (%)
1st premolar	Male	142	86 (60.56)	54 (38.03)	2 (1.41)	56 (39.44)
	Female	154	104 (67.53)	50 (32.47)	0 (0.00)	50 (32.47)
	Total	296	190 (64.19)	104 (35.14)	2 (0.67)	106 (35.81)
2nd premolar	Male	186	126 (67.74)	58 (31.18)	2 (1.08)	60 (32.26)
	Female	188	128 (68.08)	60 (31.92)	0 (0.00)	60 (31.92)
	Total	374	254 (67.91)	118 (31.55)	2 (0.53)	120 (32.09)

Table 2. Type prevalence of the cervical line on the lingual surface of maxillary premolars. P for sex (straight vs curved): first premolars 0.211; second premolars 0.943. P for tooth type: 0.311. Curved type 2 in second premolars was rare (2/374, 0.53%), both in the male subgroup.

Mesial Surface

In maxillary first premolars, the straight type was observed in only 6 teeth (2.03%), while curved type 1 was observed in 276 teeth (93.24%) and curved type 2 in 14 teeth (4.73%). The total prevalence of curved type was 97.97%. In maxillary second premolars, the straight type was observed in 6 teeth (1.60%), curved type 1 in 362 teeth (96.79%), and curved type 2 in 6 teeth (1.61%). The total prevalence of curved type was 98.40% (Table 3). When straight versus curved types were compared between sexes, Fisher exact tests showed P = 0.030 for both first and second premolars; however, these results were driven by sparse straight-type cells and should be interpreted cautiously. The tooth-type comparison was not significant (P = 0.682).

Tooth	Sex	N	Straight (%)	Curved		
				Type 1 (%)	Type 2 (%)	Total (%)
1st premolar	Male	142	0 (0.00)	128 (90.14)	14 (9.86)	142 (100.00)
	Female	154	6 (3.90)	148 (96.10)	0 (0.00)	148 (96.10)
	Total	296	6 (2.03)	276 (93.24)	14 (4.73)	290 (97.97)
2nd premolar	Male	186	0 (0.00)	180 (96.77)	6 (3.23)	186 (100.00)
	Female	188	6 (3.19)	182 (96.81)	0 (0.00)	182 (96.81)
	Total	374	6 (1.60)	362 (96.79)	6 (1.61)	368 (98.40)

Table 3. Type prevalence of the cervical line on the mesial surface of maxillary premolars. P for sex (straight vs curved): Fisher exact P = 0.030 for both first and second premolars; sparse cells. P for tooth type: 0.682.

Distal Surface

In maxillary first premolars, the straight type was observed in 29 teeth (9.80%), curved type 1 in 263 teeth (88.85%), and curved type 2 in 4 teeth (1.35%). The total prevalence of curved type was 90.20%. In maxillary second premolars, the straight type was observed in 30 teeth (8.02%), curved type 1 in 338 teeth (90.37%), and curved type 2 in 6 teeth (1.61%). The total prevalence of curved type was 91.98% (Table 4). Sex differences were not significant (first premolars: $\chi^2 = 1.297$, P = 0.255; second premolars: $\chi^2 = 0.123$, P = 0.726). The tooth-type comparison was not significant (P = 0.421).

Tooth	Sex	N	Straight (%)	Curved		
				Type 1 (%)	Type 2 (%)	Total (%)
1st premolar	Male	142	11 (7.74)	127 (89.44)	4 (2.82)	131 (92.26)
	Female	154	18 (11.69)	136 (88.31)	0 (0.00)	136 (88.31)
	Total	296	29 (9.80)	263 (88.85)	4 (1.35)	267 (90.20)
2nd premolar	Male	186	14 (7.53)	168 (90.32)	4 (2.15)	172 (92.47)
	Female	188	16 (8.52)	170 (90.42)	2 (1.06)	172 (91.48)
	Total	374	30 (8.02)	338 (90.37)	6 (1.61)	344 (91.98)

Table 4. Type prevalence of the cervical line on the distal surface of maxillary premolars. P for sex (straight vs curved): first premolars 0.255; second premolars 0.726. P for tooth type: 0.421.

Size of the Cervical Region

The intra-examiner reliability was high (Cohen's kappa = 0.91 for categorical classification; ICC = 0.94 for continuous measurements). In maxillary first premolars, the cervical width was 4.9 ± 0.02 mm and the cervical thickness was 8.1 ± 0.05 mm. In maxillary second premolars, the cervical width was 4.8 ± 0.02 mm and the cervical thickness was 8.0 ± 0.03 mm. In both tooth types, the width was consistently smaller than the thickness ($P < 0.001$) (Table 5). Sex differences were small: first-premolar width $P = 0.047$ and thickness $P = 1.000$; second-premolar width $P = 0.019$ and thickness $P < 0.001$. First versus second premolar width differed significantly ($P = 0.0004$), whereas thickness did not ($P = 0.087$).

Tooth	Sex	N	Width mean ± SE (mm)	Thickness mean ± SE (mm)
1st premolar	Male	142	4.8 ± 0.03	8.1 ± 0.05
	Female	154	4.9 ± 0.04	8.1 ± 0.04
	Total	296	4.9 ± 0.02	8.1 ± 0.05
2nd premolar	Male	186	4.8 ± 0.03	8.1 ± 0.04
	Female	188	4.7 ± 0.03	7.8 ± 0.05
	Total	374	4.8 ± 0.02	8.0 ± 0.03

Table 5. Size of the cervical region in maxillary premolars. Values are mean ± standard error (SE). Sex differences: first-premolar width $P = 0.047$, thickness $P = 1.000$; second-premolar width $P = 0.019$, thickness $P < 0.001$. First vs second premolar: width $P = 0.0004$, thickness $P = 0.087$. Width was smaller than thickness in both tooth types ($P < 0.001$).

4. DISCUSSION

The present study provides comprehensive morphometric data on the cervical line of maxillary premolars. The findings demonstrate that the morphology of the cervical line varies considerably depending on the surface examined and the tooth type. Statistical comparisons showed that sex and tooth-type differences in cervical line type were generally not significant, except for the mesial straight-versus-curved distribution, which was based on very few straight-type cases.

The mesial and distal surfaces exhibited the highest prevalence of curved type, with curved type 1 being the most common. This is consistent with previous studies reporting that proximal surfaces have greater cervical line curvature than buccal or lingual surfaces [4]. The greater curvature on proximal surfaces can be attributed to the developmental morphology of the tooth, as the cervical line follows the contour of the crown, which is more pronounced on proximal surfaces [17].

The buccal and lingual surfaces showed a higher prevalence of straight type, particularly on the lingual surface. This finding is consistent with the general anatomical principle that the cervical line is more occlusally positioned on the lingual surface than on the buccal surface in posterior teeth [4]. The lower prevalence of curvature on the lingual surface may be related to the smoother contour of the lingual surface compared to the buccal surface.

The prevalence of curved type 2 was generally low, particularly on the buccal and lingual surfaces. In maxillary second premolars, curved type 2 was absent on the buccal surface and rare on the lingual surface (2/374, 0.53%). This suggests that extreme curvature of the cervical line is relatively rare in maxillary premolars, which has implications for clinical procedures such as rubber dam clamp placement and matrix band adaptation.

The cervical dimensions observed in this study are consistent with previous morphometric studies of maxillary premolars. The width (mesiodistal dimension) was smaller than the thickness (buccolingual dimension) in both first and second premolars, which reflects the typical anatomy of premolars being wider buccolingually than mesiodistally [8]. The cervical width of approximately 4.8–4.9 mm and thickness of 8.0–8.1 mm are within the range reported in previous studies [18,19]. However, small but statistically significant sex differences were observed in cervical width and in second-premolar thickness; these differences were of limited magnitude and should not be overinterpreted.

The clinical implications of these findings are significant. First, the high prevalence of curvature on proximal surfaces necessitates careful adaptation of matrix bands and wedges during restorative procedures to prevent overhang or undercontouring. Second, the fragility of the CEJ, particularly in cases with a gap between enamel and cementum, requires meticulous handling during scaling and root planing to avoid damage to the cementum and exposure of dentin. Third, the morphological data provided in this study can be used to design instruments and materials that better adapt to the cervical region of maxillary premolars [26–30]. Nevertheless, because most sex and tooth-type comparisons were not statistically significant, clinical recommendations should remain primarily descriptive and should be confirmed in larger and more diverse samples.

The present study has several limitations. First, the sample size, while substantial, may not be representative of all populations. Second, the morphological classification was based on macroscopic observation, which may not capture fine details of the cervical line. Third, the study did not examine the tissue interrelationships at the CEJ (e.g., cementum overlapping enamel, edge-to-edge, gap), which have been extensively studied in previous research. Fourth, although intra-examiner reliability was assessed, inter-examiner reliability was not evaluated. Fifth, the sparse number of straight-type cases on mesial surfaces limits the stability of the corresponding sex comparisons. Future studies should combine macroscopic morphometry with microscopic analysis and multi-examiner reliability assessment to provide a more comprehensive understanding of the cervical region.

5. CONCLUSION

Within the limitations of this study, the cervical line of maxillary premolars demonstrated considerable morphological variation that was dependent on both tooth type and surface. The proximal surfaces were predominantly curved, whereas the buccal and lingual surfaces were more frequently straight, and extreme curvature was rare. Additionally, the cervical width was consistently smaller than the cervical thickness in both first and second premolars. Most sex and tooth-type comparisons were not statistically significant, except for sparse mesial straight-type cases and small dimensional differences; therefore, the clinical relevance of these findings should be interpreted conservatively. These findings provide comprehensive morphometric data that fulfill the study's objective of characterizing the cervical line in maxillary premolars, and they offer a clinically relevant overview of cervical morphology that may assist in restorative, periodontal, and endodontic procedures by guiding instrument selection and technique adaptation.

Conflict of Interest

The authors declare no conflicts of interest in this study.

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Authors Contribution

Conceptualization: Hong Gwang-Hyon, Kim Yong-Ho; Methodology: Hong Gwang-Hyon, Pak Hong-Jin; Formal Analysis: Yu Hong-Jin, Pak Myong-Chol; Data Curation: Pak Hong-Jin, Kim Yong-Ho; Original Draft Writing: Hong Gwang-Hyon, Pak Hong-Jin, Kim Yong-Ho; Supervision and Editing: Pak Myong-Chol, Yu Hong-Jin; Administration: Yu Hong-Jin.

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