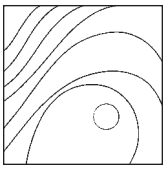
Comparative Study of Two Ways to Measure Root Trunk Length to Assess the Possibility of Crown Lengthening in Molars: Measuring Parallel to the Root Surface vs Parallel to the Tooth Axis



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This study compared root trunk measurement methods—measuring parallel to the tooth axis (TA) vs parallel to the root surface (RS)—to assess the implications for decision-making regarding crown lengthening surgery. A total of 672 root trunks were measured by CBCT in both TA and RS planes. The possibility of performing crown lengthening in each clinical situation, based on the distance from the cementoenamel junction (CEJ) to the crestal bone (CB) after ostectomy (CEJ–CB), was judged and compared between groups. The proportions of cases with CEJ–CB values of 4, 5, and 6 mm in which crown lengthening was judged possible were 83.63%, 59.08%, and 39.18%, respectively, when RS was used as a reference point. When TA was used as a reference point, those proportions decreased 3.87% to 7.29%. The lingual root trunk of the mandibular first molar (LFL) with a CEJ–CB of 4 to 5 mm emerged as the most problematic area where the decision (based on each plane) shows a high rate of inconsistency, with differences between TA and RS measurements occurring in every 1 out of 5 to 6 teeth (16.67% to 18.75%). Within the limits of this study, utilizing TA for treatment-planning of surgical crown lengthening may not be ideal, as it may lead to extraction of many teeth that could otherwise be saved. Int J Periodontics Restorative Dent 2023;43:e141–e147. doi: 10.11607/prd.5801

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Challenging situations can arise with subgingival tooth fractures or caries. In many cases, surgical crown lengthening is required to create a finish line or crown ferrule. In treatment planning, clinicians must attend to the dimensions of supracrestal attached tissues. Gargiulo et al measured the width of the dentogingival junction in humans and concluded that the average width of supracrestal attached tissues is 2.04 mm.[1] Violation of the supracrestal attached tissues may result in gingival inflammation,[2] pocket formation,[3–5] gingival recession, and alveolar bone loss.[6] To avoid these problems, a 3-mm distance between the restorative margin and the alveolar bone crest has been recommended after crown lengthening surgery.[7]

In multiple-root teeth, the key anatomical factor that affects crown lengthening surgery is the position of the furcation entrance. Ostectomy should not be performed beyond this level because it poses a threat of creating furcation involvement.[8] This condition creates an area that is very hard to clean and may lead to a worsened tooth prognosis.[9–11] Knowledge of each tooth's root trunk length and the distance from the cementoenamel junction (CEJ) to the furcation entrance may prove essential for treatment planning and predicting surgical results. Although many previous studies have measured the average root trunk length,

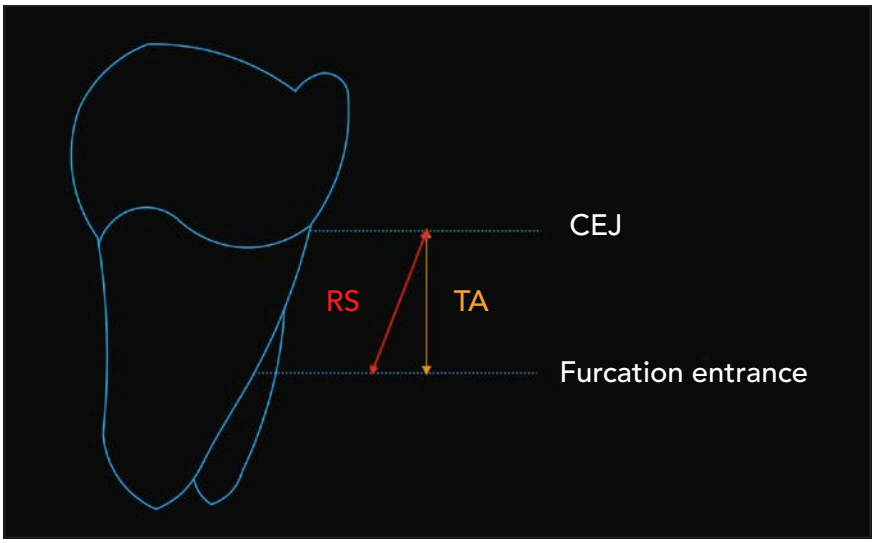

Fig 1 *Schematic drawing of the root trunk length, as measured parallel to the root surface (RS) and parallel to the root trunk axis (TA).*

the results varied extensively according to the subject population and measuring method. For example, one study found that the average buccal root trunk length of the mandibular first molar was 1.45 mm[12] in a Taiwanese population, while another study reported a length of 3.27 mm in a US population.[13]

One very important factor is the plane in which the root trunk is measured. Many studies have measured root trunk length parallel to the tooth axis.[12–18] However, in the surgical field, surgeons often measure root trunk length parallel to the tooth surface. The two methods yield different values, the difference between which may affect the decision to save or extract the tooth. The first objective of this study is to compare the measurements of root trunk length in two planes: parallel to the root surface and parallel to the tooth axis. The second objective is to compare the possibility of performing crown lengthening based on the length of the root trunk as assessed in each of the two planes.

Materials and Methods

The study protocol was approved by the Research Ethics Committee of Rangsit University. Radiographic images of Thai adults who had been radiographed by CBCT in Rangsit University's College of Dental Medicine between 2014 and 2018 were recruited for this study. All participant permission has been given by written consent form. The inclusion criteria were that the radiograph must include an upper or lower molar with at least two separate roots. The area around the CEJ and the root trunk had to be sound, without cavities or restoration. Radiographs of 362 teeth (672 root trunks) were obtained from 76 patients.

Root trunk lengths were measured (Fig 1) parallel to root surface (RS) and parallel to the tooth axis (TA) by five observers (T.C., T.M., M.P., A.P., and C.S., all trained by the first author prior to taking measurements) using the CS 3D Suite program (version 3.7.10, Carestream Dental) in oblique slicing mode. The measurements were divided into 10 site categories: buccal (LFB) and lingual (LFL) root trunks of the mandibular first molar; buccal (LSB) and lingual (LSL) root trunks of the mandibular second molar; buccal (UFB), mesial (UFM), and distal (UFD) root trunks of the maxillary first molar; and buccal (USB), mesial (USM), and distal (USD) root trunks of the maxillary second molar.

Each root trunk site was measured by one observer (randomly selected from thr group of five observers) at least twice. Interpretations were separated by breaks of at least 10 minutes to relieve eye strain. If the values found on first and second interpretation differed by more than 0.5 mm, the interpretation was repeated. If the values differed by 0.5 mm or less, the average of the two values was used.

The possibility of performing crown lengthening in each clinical situation, based on the distance from the cementoenamel junction (CEJ) to the crestal bone (CB) after ostectomy (CEJ–CB), was judged and compared between groups.

To replicate real clinical situations, decisions as to whether it would be possible to perform crown lengthening were based on the calculated distance from the CEJ to the crestal bone (CB) after ostectomy (CEJ–CB). CEJ–CB values of 4 mm, 5 mm, and 6 mm were calculated based on the amount of tooth structure loss below

the CEJ level (TL) and the ferrule requested (FR), as shown in Table 1. Calculations used a supracrestal attachment distance of 3 mm, as described by Ingber et al.[7] If the root trunk length was equal to or greater than CEJ–CB, the tooth was graded as "possible" (a candidate for crown lengthening). Any tooth with a shorter root trunk was classified as "not possible."

SPSS (version 20, IBM) was used to perform statistical analyses. Paired *t* test and Wilcoxon signed-rank test were used to analyze the differences between TA and RS of the molar teeth. To check the effects of the different planes on treatment decisions, a chi-square test was used. The significance level that allowed either rejecting the null hypothesis or accepting the alternative hypothesis was set at 0.05.

Table 1 Calculated CEJ–CB Levels in Real Clinical Situations

CEJ–CB distance, mm	TL, mm	FR, mm
4	0	1
4	1	0
5	0	2
5	1	1
5	2	0
6	1	2
6	2	1
6	3	0

CB = crestal bone; CEJ = cementoenamel junction; FR = ferrule requested; TL = tooth structure loss below the CEJ level.

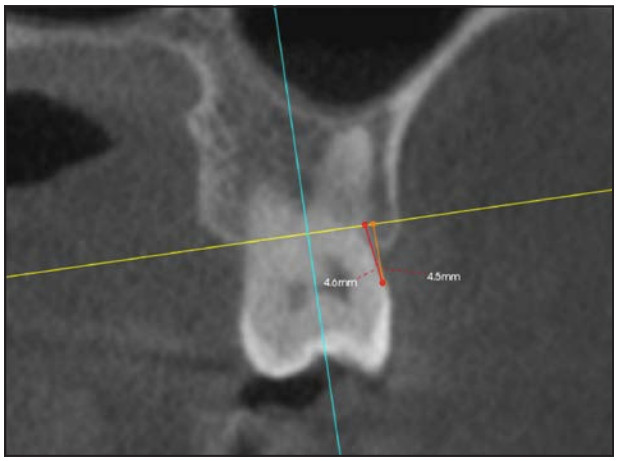

Fig 2 *The buccal root trunk length of a maxillary first molar (UFB) was measured on a CBCT scan according to RS (red line) and TA (orange line) methods. The furcation entrance (yellow line) was identified by the first axial plane where the mesiobuccal and distobuccal roots were completely separate. The blue line indicates the long axis of the tooth.*

Results

The intraclass correlation coefficients (ICCs) in this study were 0.948 to 0.994, indicating excellent reliability. The numbers of root trunk sites and the average RS and TA root trunk lengths are listed in Table 2. An example CBCT scan of RS and TA measurements at a UFB site are shown in Fig 2.

RS root trunk lengths were statistically different from TA lengths, with an average difference of approximately 0.25 mm. Moreover, 88.24% of RS root trunk lengths were greater than the TA lengths, with a difference > 0.5 mm in 15.92% of all sites. The proportion of sites showing a difference increased even more at the LSL, LFL, and USB, where the incidence of a difference > 0.5 mm was 27.12%, 33.33%, and 35.00%, respectively (Table 3).

The number of teeth for which it was possible to perform crown lengthening in each clinical situation is shown in Tables 4 to 6. When RS was used as the reference point, crown lengthening was possible for 83.63%, 59.08%, and 39.18% of cases with CEJ–CB values of 4, 5, and 6 mm, respectively. When TA was used as the reference point, the percentages decreased to 76.34%, 51.93%, and 29.61%, respectively. There was a statistical difference between the two reference planes at CEJ–CB values of 4 and 5 mm but not at CEJ–CB value of 6 mm (Table 7).

Discussion

The possibility of performing crown lengthening is critically important, as it determines whether the tooth in question can be saved or needs to be extracted. The plane in which the root trunk length is measured is an essential factor to consider for multiple-root teeth. To avoid furcation exposure, some surgical plans

Table 2 Mean Root Trunk Lengths at Each Site

Site	n	RS measurement, mm		TA measurement, mm		Average difference	*P*
		Mean	SD	Mean	SD		
Mandible							
First molar							
Buccal (LFB)	38	4.15	1.27	3.94	1.34	0.21	.000[a]
Lingual (LFL)	48	4.78	0.97	4.38	0.96	0.39	.000[a]
Second molar							
Buccal (LSB)	50	5.77	1.61	5.46	1.66	0.27	.000[a]
Lingual (LSL)	59	5.76	1.16	5.41	1.15	0.35	.000[a]
Maxilla							
First molar							
Buccal (UFB)	79	4.85	1.35	4.71	1.37	0.14	.000[b]
Distal (UFD)	85	5.35	1.35	5.08	1.39	0.27	.000[a]
Mesial (UFM)	74	6.00	1.26	5.85	1.27	0.15	.000[a]
Second molar							
Buccal (USB)	60	4.57	1.28	4.20	1.34	0.37	.000[a]
Distal (USD)	97	5.48	1.54	5.22	1.55	0.27	.000[a]
Mesial (USM)	82	6.51	1.39	6.37	1.47	0.14	.000[a]
Total	672	5.41	1.54	5.16	1.54	0.25	.000[a]

P values < .05 were considered statistically significant.
[a]Paired *t* test (two-tailed).
[b]Wilcoxon signed-rank test (two-tailed).

Table 3 Comparative Data for RS and TA Trunk Length Measurements

Site	n	RS > TA		RS−TA ≥ 0.5 mm	
		n	%	n	%
LFB	38	33	86.84	6	15.79
LFL	48	42	87.50	16	33.33
LSB	50	47	94.00	7	14.00
LSL	59	57	96.61	16	27.12
UFB	79	54	68.35	6	7.59
UFD	85	83	97.65	11	12.94
UFM	74	66	89.19	3	4.05
USB	60	54	90.00	21	35.00
USD	97	88	90.72	14	14.43
USM	82	69	84.15	7	8.54
All	672	593	88.24	107	15.92

See Table 2 for an explanation of site abbreviations.

Table 4 Number of Teeth Deemed Eligible for Crown Lengthening (CEJ–CB = 4 mm)

		RS		TA		Difference	
Site	n	n	%	n	%	n	%
LFB	38	21	55.26	17	44.74	4	10.53
LFL	48	40	83.33	31	64.58	9	18.75
LSB	50	43	86.00	38	76.00	5	10.00
LSL	59	57	96.61	54	91.53	3	5.08
UFB	79	61	77.22	54	68.35	7	8.86
UFD	85	72	84.71	65	76.47	7	8.24
UFM	74	70	94.59	69	93.24	1	1.35
USB	60	40	66.67	32	53.33	8	13.33
USD	97	81	83.51	76	78.35	5	5.15
USM	82	77	93.90	77	93.90	0	0.00
Total	672	562	83.63	513	76.34	49	7.29

See Table 2 for an explanation of site abbreviations.

Table 5 Number of Teeth Deemed Eligible for Crown Lengthening (CEJ–CB = 5 mm)

		RS		TA		Difference	
Site	n	n	%	n	%	n	%
LFB	38	9	23.68	7	18.42	2	5.26
LFL	48	19	39.58	11	22.92	8	16.67
LSB	50	30	60.00	27	54.00	3	6.00
LSL	59	45	76.27	37	62.71	8	13.56
UFB	79	34	43.04	30	37.97	4	5.06
UFD	85	49	57.65	43	50.59	6	7.06
UFM	74	60	81.08	57	77.03	3	4.05
USB	60	21	35.00	17	28.33	4	6.67
USD	97	59	60.82	51	52.58	8	8.25
USM	82	71	86.59	69	84.15	2	2.44
Total	672	397	59.08	349	51.93	48	7.14

See Table 2 for an explanation of site abbreviations.

have had to follow average root trunk lengths taken from previous studies, which have mostly reported lengths measured in TA. When the value of CEJ–CB exceeds the root trunk length, the tooth in question is judged as ineligible for crown lengthening. However, surgeons tend to use RS, measuring the extent of bone grinding in the surgical field by placing a periodontal probe parallel to tooth surface. Data from the present study show that in nearly 90% of molars, root trunk length measured in RS is longer than root trunk length measured in TA. As a result, RS measurements usually indicate that the amount of bone a periodontist can reduce without disturbing the furcation area is greater than it would appear in treatment-planning based on TA measurements. Misjudgments can occur when the CEJ–CB is greater in TA and smaller in RS

Table 6 Number of Teeth Deemed Eligible for Crown Lengthening (CEJ–CB = 6 mm)

		RS		TA		Difference	
Site	n	n	%	n	%	n	%
LFB	38	2	5.26	2	5.26	0	0.00
LFL	48	5	10.42	2	4.17	3	6.25
LSB	50	21	42.00	19	38.00	2	4.00
LSL	59	22	37.29	19	32.20	3	5.08
UFB	79	13	16.46	13	16.46	0	0.00
UFD	85	24	28.24	22	25.88	2	2.35
UFM	74	35	47.30	31	41.89	4	5.41
USB	60	8	13.33	4	6.67	4	6.67
USD	97	38	39.18	32	32.99	6	6.19
USM	82	57	69.51	55	67.07	2	2.44
All	672	225	33.48	199	29.61	26	3.87

Table 7 Comparison of Crown Lengthening Treatment Decisions Made Between Groups

		Possible with RS		Possible with TA		
CEJ–CB	n	n	%	n	%	*P*[a]
4 mm	672	562	83.63	513	76.34	.001
5 mm	672	397	59.08	349	51.93	.008
6 mm	672	225	33.48	199	29.61	.725

P values < .05 were considered statistically significant.
[a]Chi-square test.

measurements. In the present study, the incidence of this situation was around 7% when CEJ–CB was 4 to 5 mm at all sites, increasing dramatically to 16.67% to 18.75% (one out of every 5 or 6 teeth) at the lingual root trunk of the mandibular first molar (LFL). When the CEJ–CB value is 6 mm, the difference between groups matters less because of the small number of teeth that can be lengthened in that condition (around 30%). To prevent this problem, RS may be a more-reliable reference point in treatment-planning for surgical crown lengthening.

The root trunk length itself also has a direct effect on this matter. A shorter root trunk results in a lesser amount of potential bone reduction. The most unfavorable condition occurred at LFB, the area with the shortest root trunk length. Surgery was possible for about 50% of LFB cases when the CEJ–CB was 4 mm, but the rate of candidates for surgery decreased to 25% when the CEJ–CB was 5 mm. The worst-case scenario occurred when the CEJ–CB value was 6 mm, with the rate of candidates for surgery decreasing to one out of 20 (5%). Attempts to save these teeth in the absence of sufficient supracrestal tissue may result in compromised tooth condition. Dibart et al studied 19 mandibular first molars and found that 42.1% of them developed furcation involvement within 5 years of receiving a crown lengthening procedure. Interestingly, the average distance between the restorative margin and furcation entrance was only 2.38 mm.[19]

Two additional factors of concern are the TL and FR. These two factors increase the value of CEJ–CB, which in turn decrease the chances of being able to lengthen the tooth. When

there is no FR, a TL of 1 mm results in successful crown lengthening odds of around 80%. Unfortunately, when more loss has occurred and the TL is 2 mm or 3 mm, those odds decrease to 60% and 30%, respectively.

The amount of FR has a similar effect. For nonvital teeth, adequate ferrules may significantly reduce the incidence of tooth fracture.[20] The ideal ferrule for crown restoration is 1 to 2 mm.[21] When TL is only 1 mm, the chances of being able to create a 1-mm ferrule are 60%. Unfortunately, those chances decrease by half if a 2-mm ferrule is required. This may be the reason that periodontists often refuse to attempt creating a 2-mm ferrule in many cases.

In the present study, CBCT was used to measure root trunk length. The data from a recent study found no statistically significant difference between actual tooth dimensions and CBCT measurement of root trunk length.[22] In surgical crown lengthening for molars, CBCT may prove useful and offer a more accurate prediction of root trunk length than using average root trunk length data from previous studies alone.

Conclusions

Root trunk length measured with a TA method, as reported in previous studies, have different values then lengths measured with an RS method. Utilizing TA for treatment-planning of surgical crown lengthening may not be ideal, as it reduces the amount of bone for possible grinding, and it may lead to unjustified extraction of many teeth that can otherwise be saved.

Acknowledgments

All authors declare no conflicts of interest.

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