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# Change in Working Length at Different Stages of Instrumentation as a Function of Canal Curvature

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## BACKGROUND

Working length (WL) determination is a fundamental step in the biomechanical preparation of the root canal system which directly impacts treatment outcome. Many studies have shown that the prognosis of periapical healing is associated with the length of obturation. Most endodontists limit the extent of obturation to the region of the apical constriction at 0.5 to 1 mm from the apical foramen, based on the findings of the classic studies of apical anatomy. Historically, working length determination was achieved by radiographs alone, a modality that has many inherent limitations. The development of the electronic apex locator has made working length determination more convenient and accurate. Studies have shown that coronal flaring of the root canal leads to greater accuracy of working length determination. However, few studies have investigated the change in working length after coronal flaring and completion of instrumentation. Vasconcelos et al found in their in vitro study an average reduction of working length of 0.34 mm and 0.6 mm after flaring and instrumentation respectively. In their study, only straight canals (curvature < 25°) were evaluated, and coronal flaring and instrumentation were completed with a single WaveOne Primary instrument. The present study was undertaken with a modified study design based on that of Vasconcelos et al to allow for a more traditional instrumentation approach utilizing Gates Glidden drills in coronal flaring and a continuous rotary file system with a constant taper. The effect of canal curvature was also assessed.

## OBJECTIVE

The aim of this in vitro study was to evaluate the change in working length at various stages of mechanical preparation via direct visualization and electronic apex locator measurements as a function of canal curvature.

## MATERIALS & METHODS

One mesiobuccal or mesiolingual canal from each of 43 extracted molars had coronal standardization and access performed. Once the access was completed, canal preparation was accomplished using #2 and #3 Gates Glidden drills for coronal flaring and .04 taper EndoSequence files for rotary instrumentation to either a master apical file size of #30 or #35 depending on root curvature. Working lengths were obtained at 3 time points: pre-instrumentation (unflared), mid-instrumentation (flared) and post-instrumentation (concluded). Measurements were made via direct visualization (DV) and the CanalPro apex locator (EM) in triplicate by a single operator with blinding within the time points. Root curvature was measured using Schneider's technique. Change in working length was assessed using repeated-measures ANCOVA. All analyses were performed using SAS software (JMP Pro version 13.2.1, SAS version 9.4, SAS Institute Inc., Cary NC) at alpha = 0.05 level of significance.

## RESULTS

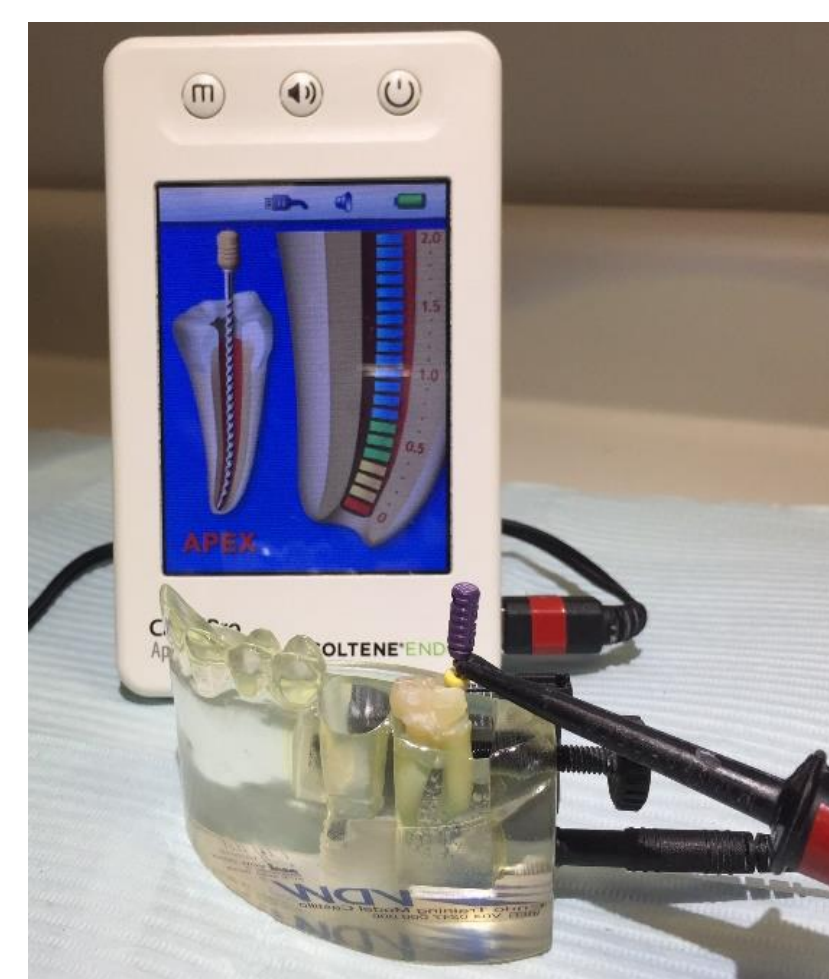


Figure 1. Setup for electronic measurement

Table 1. Overall  $\Delta$ WL depending upon Time and Technique

Time	Technique	$\Delta$ WL (mm)	95% CI	P-value*
Flared	DV	-0.0688	-0.1196 -0.0179	0.3298
	EM	-0.0878	-0.1387 -0.0370	
Concluded	DV	-0.3139	-0.3648 -0.2631	0.0030
	EM	-0.2556	-0.3065 -0.2047	

Abbreviations: DV=direct visualization, EM=electronic measurement,  $\Delta$ WL=estimated average change in working length as compared to the average unflared measurement, 95% CI=95% confidence interval  
\*P-values, estimates, and confidence intervals estimated from a repeated-measures mixed model ANCOVA. The estimates are for the average unflared root length (18.68 mm) and the average curvature (27.69°). The P-value compares the DV and EM estimates at the specified Time.

- In this sample of 43 roots, the average curvature was 27.69° (SD = 10.00°, range = 9.92° to 50.05°). The average root length (unflared WL) was 18.78 mm by direct visualization (SD = 1.54, range = 14.88 to 21.19) and 18.58 mm by electronic measurement (SD = 1.56, range = 14.64 to 22.07). DV values were significantly greater than EM values (paired t-test difference = **0.20 mm**, SE = 0.037, P < .0001).
- A relationship between root length and root curvature was observed in this sample, where shorter roots tended to have greater curvature and longer roots tended to have less curvature.
- Table 1 shows that for the average canal length (18.68 mm) and the average curvature (27.69°), average  $\Delta$ DV<sub>flared</sub> (0.07 mm) and  $\Delta$ EM<sub>flared</sub> (0.09 mm) were not significantly different whereas average  $\Delta$ DV<sub>concluded</sub> (0.31 mm) and  $\Delta$ EM<sub>concluded</sub> (0.26 mm) were significantly different.

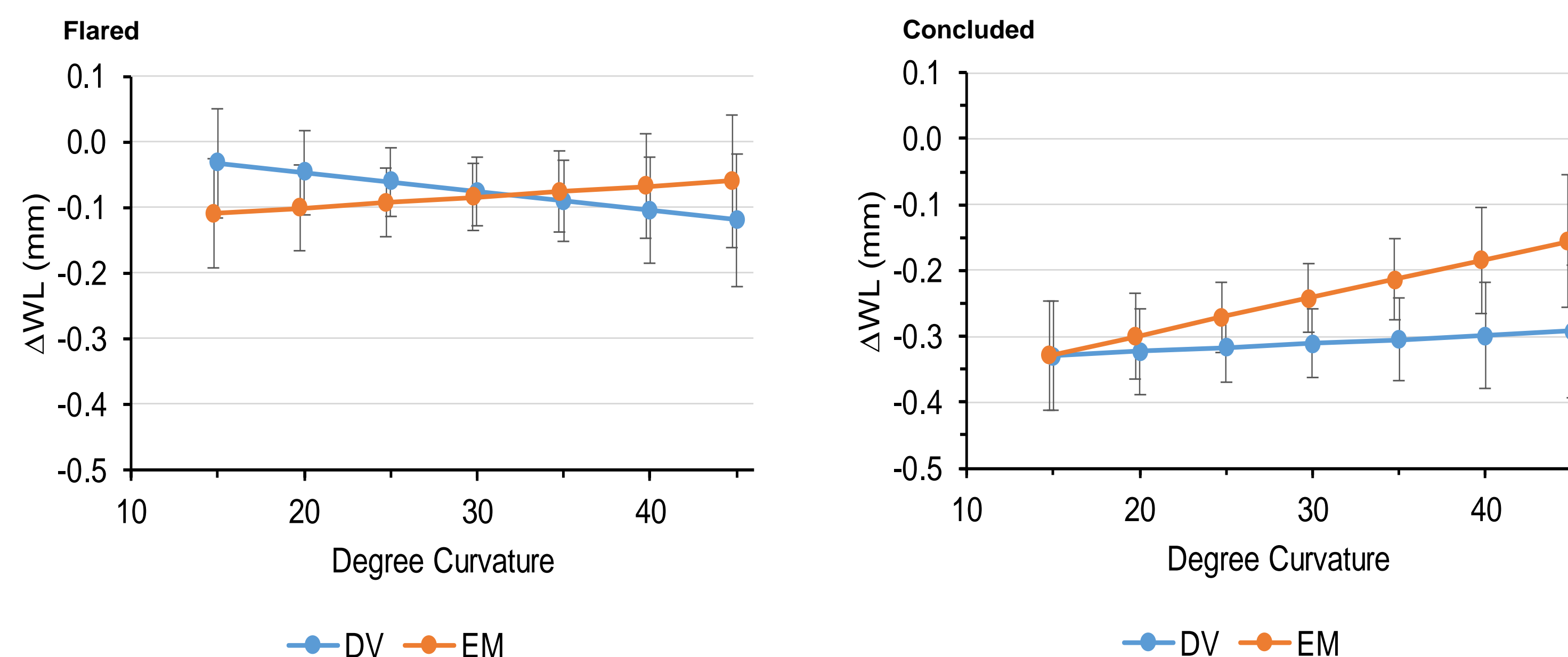


Figure 2.  $\Delta$ WL depending upon Curvature and Technique for the Flared and Concluded time points

Figure 2 shows that at the flared stage, as root curvature increased, there was a greater loss of WL detected by DV but a smaller loss of WL by EM. At the concluded stage, as root curvature increased, there was a smaller loss of WL detected by both DV and EM, but the trend was more obvious with EM.

## ACKNOWLEDGMENT

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## DISCUSSION

From the unflared to the concluded time points, an average loss of working length of 0.26 mm and 0.31 mm were found via DV and EM respectively. Clinically, a 0.5 mm difference in working length is discernible visually. However, it may be much more difficult to consistently discern a 0.25 mm difference. Therefore, a limited degree of clinical significance may be extrapolated.

Overall in this study, a greater curvature correlated to a smaller loss of WL. This finding was counter-intuitive as one would expect a canal with greater curvature to undergo greater canal straightening and therefore greater loss of working length. This unexpected finding might be attributed to the limitations of the study. Canal curvature was only evaluated in a mesiodistal dimension radiographically. The sample size was limited and the relationship between canal curvature and length might be a confounding factor. Human error in direct visualization was attributed to inconsistent identification of apical reference point, which was also complicated by operator blinding within time points. Master apical file sizes were not standardized for curvature or recorded for retrospective analysis.

Vasconcelos et al found an average reduction of working length of 0.34 mm and 0.6 mm after flaring and instrumentation respectively. The discrepancy of change in working length between the 2 studies may be attributed to the differences in study design with regard to canal curvature and instrument taper.

## CONCLUSION

In this study, a greater change in working length was observed in straight canals than in curved canals. This trend was more pronounced when measured electronically than via direct visualization, especially in the unflared-concluded time points compared with unflared-flared time points. A greater change in working length was also observed in longer canals than in shorter canals. Due to the small amount of change in working length found in this study, a limited degree of clinical significance may be extrapolated.

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