Endodontic Instrumentation via Angulated Access – Artificial Oral Cavity in-vitro Study

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Objectives:

Microinvasive endodontic treatment is based on hard tissue conservation and different carious access cavities: occlusal caries lesion 15° (posterior teeth), mesial caries lesion 30° (posterior teeth) and cervical carious or wear lesion 45° (posterior and front teeth). Caries free teeth with no wear will be accessed in 0° angulation (not shown here). Therefore, the aim was (i) to create an Artificial Oral Cavity (AOC) for clinical simulation of these three access cavities, (ii) to assess the biomechanics of blinded instrumentation and (iii) to measure the volumetric loss of simulated dentin caused by four different preparation systems.

Material and Methods:

Simulated s-shaped root canals with medium degree of obliteration in acrylic polymer bodies with canal entrance angles 15°, 30° and 45° were wet shaped with NaOCl (3%), at body temperature in randomized blinded sequences (n = 7) according to manufacturers´ instructions.

Type of instruments:

1. Conventional geometry, not heat treated, up to size 35/.04 (F360, Komet)
2. Conventional geometry, heat-treated, spark-eroded up to size 40/.04 (Hyflex EDM, Coltene)
3. Off-centered geometry, heat treated, up to size 36/.03 (TruNatomy, DentsplySirona)
4. Off-centered geometry, heat-treated, up to size 30/.04 (XP-Endo Shaper, SwissEndo)

Vectorization (AutoCAD) of the whole root canal was performed before and after preparation, summarized in apical, middle and coronal thirds. Volumetric shaping and dentin loss was recorded and statistically evaluated using independent two-sided t-test.

Results:

Total volume loss at 15° access was significantly lowest with TruNatomy and XP-Endo. At 30°, total loss remained low and increased with F360 and Hyflex. At 45° the group differences remained: TruNatomy (6.5 mm³) and XP-Endo (6.4 mm³) versus F360 (8.3 mm³) and Hyflex (8.4 mm³). This difference was highly significant.

Conclusions:

Conventional instruments achieve optimal shape of apical third of root canal via all entrance angles only with high loss of simulated dentin along coronal and middle thirds. In contrast, off-centered instrument geometry contributes to dentin protection and supports the concept of minimally invasive endodontics for lifelong tooth preservation.

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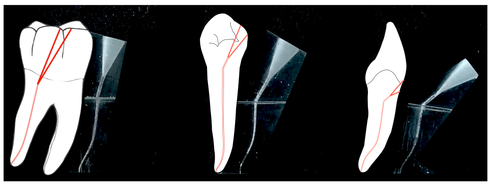

Fig. 1: Clinically simulated root canals and canal access angles of 15°, 30° and 45°.

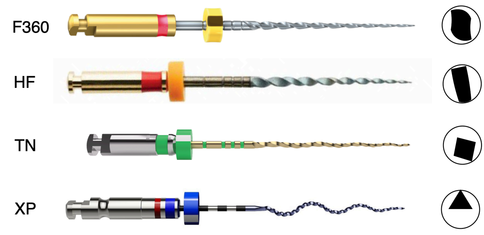

Fig. 2: Investigated instruments with the corresponding cross-sections: F360: Komet F360, HF: HyFlex EDM, TN: TruNatomy and XP: XP-Endo Shaper.

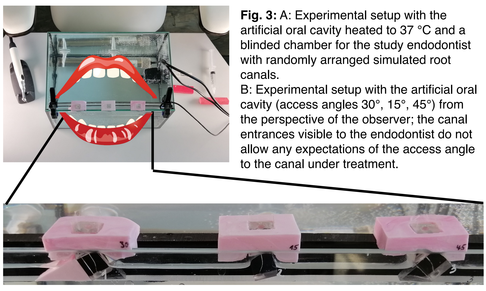

Fig. 3: A: Experimental setup with the artificial oral cavity heated to 37 °C and a blinded chamber for the study endodontist with randomly arranged simulated root canals.
B: Experimental setup with the artificial oral cavity (access angles 30°, 15°, 45°) from the perspective of the observer; the canal entrances visible to the endodontist do not allow any expectations of the access angle to the canal under treatment.

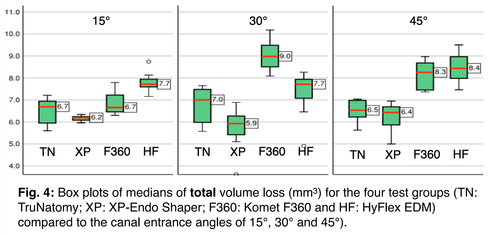

Fig. 4: Box plots of medians of **total** volume loss (mm³) for the four test groups (TN: TruNatomy; XP: XP-Endo Shaper; F360: Komet F360 and HF: HyFlex EDM) compared to the canal entrance angles of 15°, 30° and 45°).

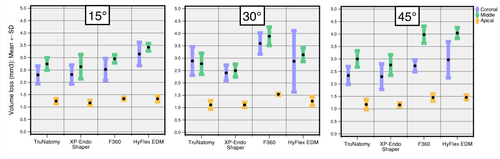

Fig. 5: Error bars of means of coronal, middle and apical volume loss for the four test groups with access cavities of 15°, 30° and 45°.

Tab. 1: Results of t-test of volume loss (VL) in the coronal, middle and apical thirds of root canals and the total volume loss at 45° canal entrance angles between the different preparation systems. TruNatomy and XP-Endo files are significantly less invasive to dentin than the two conventional file systems (green: highly significant, yellow: not significant after Bonferroni correction).

Comparison	Area / Segment resp. Parameter	Statistics			
		t	df	p	Mean difference
TruNatomy vs. XP-Endo Shaper	Coronal VL	0.188	12	0.854	0.044
	Middle VL	1.234	12	0.241	0.244
	Apical VL	0.173	7.534	0.867	0.014
	Total VL	0.911	12	0.380	0.303
TruNatomy vs. F360	Coronal VL	-2.261*	11	0.045	-0.390
	Middle VL	-5.296***	11	0.000	-0.974
	Apical VL	-2.790*	11	0.018	-0.281
	Total VL	-4.870***	11	0.000	-1.644
TruNatomy vs. HyFlex EDM	Coronal VL	-2.069	12	0.061	-0.633
	Middle VL	-7.064***	12	0.000	-1.037
	Apical VL	-3.307**	8.510	0.010	-0.284
	Total VL	-5.484***	12	0.000	-1.954
XP-Endo Shaper vs. F360	Coronal VL	-1.900	11	0.084	-0.434
	Middle VL	-5.737***	11	0.000	-1.218
	Apical VL	-4.724***	11	0.001	-0.295
	Total VL	-5.075***	11	0.000	-1.947
XP-Endo Shaper vs. HyFlex EDM	Coronal VL	-2.018	12	0.066	-0.677
	Middle VL	-7.267***	12	0.000	-1.281
	Apical VL	-6.490***	12	0.000	-0.299
	Total VL	-5.732***	12	0.000	-2.257
F360 vs. HyFlex EDM	Coronal VL	-0.836	7.461	0.429	-0.243
	Middle VL	-0.407	11	0.692	-0.063
	Apical VL	-0.049	11	0.961	-0.003
	Total VL	-0.760	11	0.463	-0.310