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Positive and negative pressure irrigation in oval root canals with apical ramifications: a computational fluid dynamics evaluation in micro-CT scanned real teeth

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Abstract-

Aim

To compare with computational fluid dynamics (CFD) the flow pattern, irrigant velocity, apical pressure and shear stress produced by negative (MiC) and positive pressure with different types of needles (side-vented (SV), front-vented (FV) and notched (N)) at two insertion depths in the apical ramification of oval root canals.

Methodology

The micro-CT of a mandibular molar with an oval root canal with an apical ramification was used for computational analysis after preparation and geometric reconstruction. Geometries with the needles in two positions (1 mm and 3 mm from WL) were created to run the simulations. Key parameters of irrigation were displayed with CFD and compared.

Results

The penetration depth of the needle in the root canal strongly influenced shear stress and apical pressure. The 3 needles revealed that the highest shear stress, velocity and apical pressure were 1 mm from the WL and generated medium velocities. In N simulations, the fluid flow did not reach the apical ramification and the lowest shear stress values for positive pressure needles were found. The predominant axial component for FV revealed a different pattern of irrigation with high shear stress values and higher apical pressures than those exerted by other needles. SV simulations had generalized fluid flow in most of the main canal, the highest shear stress values and lower apical pressure than the threshold determined for risk of extrusion. MiC was associated with low velocity, shear stress and apical pressure.

Conclusion

The SV needle demonstrated a combination of low positive pressure and high shear stress; while N had the lowest shear stress and FV the highest apical pressure. MiC generated fluid flow in part of the apical ramification with negative apical pressure values but low shear stress and velocity.

Index Terms- apical delta, computational fluid dynamics, microCT, negative pressure irrigation, positive pressure irrigation

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