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Comparative Evaluation Of Canal Transportation, Centering Ability, And Remaining Dentin Thickness Between Hyflex CM, Protaper Gold, And Protaper Next Rotary Systems Using Cone Beam Computed Tomography: An In Vitro Study

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Abstract
Comparative evaluation of Canal Transportation, Centering Ability, and Remaining Dentin Thickness between Hyflex CM and ProTaper Next rotary by using cone beam computed tomography: An in vitro study.
Materials and Methods: *The study was conducted on sixty extracted human single-rooted premolars. Pre-instrumentation scanning of all teeth was taken, canal curvatures were calculated, and the samples were randomly divided into three groups, with twenty samples in each group; one group was instrumented with Hyflex CM system and the other group with ProTaper Gold and ProTaper Next rotary system. Post-instrumentation scans were performed, and the two scans will be compared to determine Canal Transportation, Centering Ability, and Remaining Dentin Thickness at 3 mm, 6 mm, and 9 mm from the root apex.*
Statistical Analysis: *The data was statistically analyzed with the ANOVA test to compare the Centering Ability, Canal Transportation, and Remaining Dentin Thickness between the experimental groups*
Results: *In our study, least Centering Ability, Canal Transportation, and Remaining Dentin Thickness were observed in ProTaper Gold. A significant difference was seen between Hyflex CM and ProTaper Next.*
Conclusion: *Hyflex CM and ProTaper Next showed considerably good results compared to ProTaper Gold*
Keywords: *Canal Transportation, Centering Ability, Dentin thickness and cone beam computed tomography, ProTaper Next, Hyflex CM, ProTaper Gold.*

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I. Introduction:

Successful endodontic therapy depends on effective cleaning and shaping of the root canal while strictly preserving its original anatomy. Instruments must conform to the canal's shape to maximize debridement and minimize unnecessary removal of dentin that could weaken the tooth. This is especially challenging in curved canals, where preparation techniques naturally tend to straighten the canal, increasing the risk of procedural errors and weakening of the root.

Two critical performance metrics in root canal preparation are Centering Ability and Remaining Dentin Thickness (RDT). Centering Ability refers to a file's capacity to remain centered within the canal during preparation, ensuring an even distribution of irrigants and filling material. Preserving sufficient RDT safeguards the tooth's structural integrity post-treatment.

Canal transportation describes the undesirable removal of dentin from the outer wall of a curved canal, typically in the apical third. This occurs when instruments return to their straight form, causing lodging, straightening of the canal, debris retention, and potential weakening of the root leading to fracture. This type of deviation is a common mishap during curved canal instrumentation and is influenced by factors such as instrument rigidity, improper access, inadequate irrigation, unrecognized canal curvatures, tip design, and operator skill.

Modern heat-treated nickel-titanium (NiTi) file systems—ProTaper Gold, ProTaper Next, and Hyflex CM—have been developed to address these challenges:

ProTaper Gold features a convex triangular cross-section with variable taper and a specialized heat treatment that increases both flexibility and strength. It demonstrates improved centering in curved canals compared to traditional NiTi systems.

ProTaper Next employs an off-centered rectangular cross-section, which creates a "swaggering" motion and frees up space for debris removal. Made from M Wire alloy, it offers good flexibility and resistance to cyclic fatigue, contributing to effective shaping.

Hyflex CM, crafted from a novel controlled memory CM Wire, provides exceptional flexibility and fatigue resistance with minimal shape memory. This allows it to closely follow natural canal anatomy, reducing the risk of lending, perforation, or transportation. Some versions can even regain their shape after autoclaving.

These systems have been evaluated using cone beam computed tomography (CBCT), which offers high-resolution, 3D, quantitative assessments of shaping outcomes, including canal transportation, centering ability, and RDT. CBCT studies have shown that while all three systems generally maintain canal anatomy well, ProTaper Next and Hyflex CM may cause less transportation in certain scenarios.

II. Materials And Methods:

Sixty freshly extracted single-rooted human premolars were selected, ensuring similar anatomical features and curvature. The teeth were decorated to a standardized root length of 18 mm and embedded in acrylic blocks. Pre-instrumentation CBCT scans were taken. Samples were divided into three groups:

Group 1: HyFlex CM (Coltene)
Group 2: ProTaper Next (Dentsply Maillefer)
Group 3: ProTaper Gold (Dentsply Sirona)

Each root canal was instrumented using the respective rotary system per the manufacturer's instructions. Post-instrumentation scans were performed with Acteon X-Mind Prime CBCT, and axial images at 3 mm, 6 mm, and 9 mm from the apex were analyzed using DICOM software. Parameters measured included canal transportation, centering ability (using Gambil's formula), and remaining dentin thickness.

III. Results:

Canal Transportation:
ProTaper Next: 0.00 ± 0.00 mm (least transportation)
HyFlex CM: 0.10 ± 0.03 mm
ProTaper Gold: 0.14 ± 0.04 mm (highest transportation)
Centering Ability:
ProTaper Next: 1.00 ± 0.44 (best centering)
HyFlex CM: 3.00 ± 1.45
ProTaper Gold: 4.50 ± 1.74 (least centering ability)
Remaining Dentin Thickness (RDT):
HyFlex CM preserved the most dentin at all levels.
ProTaper Gold removed the most dentin, especially at the 3 mm and 9 mm levels.
Statistical significance ($p<0.05$) was observed for RDT comparisons at 3 mm and 9 mm.

IV. Discussion:

ProTaper Next demonstrated the best overall shaping performance with minimal canal transportation and optimal centering. Its unique off-centered rectangular cross-section and M-wire technology allow efficient debris removal while preserving canal anatomy. HyFlex CM, known for its controlled memory and flexibility, maintained maximum dentin thickness, especially in apical regions, making it suitable for conservative instrumentation. ProTaper Gold, although offering excellent cutting efficiency, showed increased canal transportation and greater dentin loss due to its aggressive design.

These findings corroborate previous studies indicating the superior shaping ability of ProTaper Next and the conservative preparation offered by HyFlex CM. However, ProTaper Gold may still be preferred in cases requiring rapid enlargement but should be used with caution in teeth with thin dentinal walls.

V. Conclusion:

ProTaper Next is recommended for its centering and canal-shaping precision. HyFlex CM is ideal for dentin preservation, particularly in teeth requiring conservative approaches. ProTaper Gold, while effective, may risk structural compromise due to aggressive dentin removal. Clinicians should select file systems based on case-specific anatomical challenges and treatment objectives.

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