

三种机用镍钛器械以不同技术预备弯曲根管的效果比较

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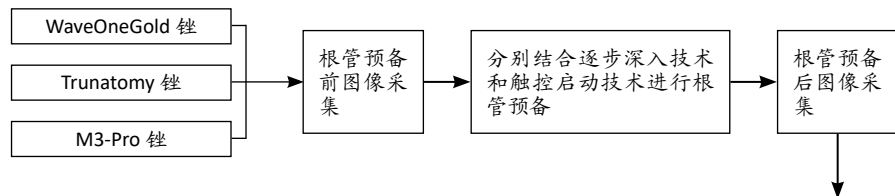
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文章快速阅读: 3种镍钛器械分别结合逐步深入和触控启动技术预备根管成形的效果



使用软件将预备前后的根管图像进行重叠, 分析预备前后根管内外侧树脂去除量, 计算根管的偏移量。结果表明: 使用触控启动技术可以减小弯曲根管部分位点的偏移量; Trunatomy 在预备弯曲根管时产生的偏移量最小, 具有较大的临床应用前景。

文题释义:

逐步深入技术: 由GOERIG于1982年提出, 是对逐步后退技术的一种改良, 适用于弯曲根管的预备。逐步深入技术的原理是在冠部入口预备完成后, 先通过用手用锉和G钻完成根管入口的制备, 去除冠方阻碍, 然后行根尖区的预备。

触控启动技术: 由CHANIOTIS和FILIPPATOS于2016年提出的用于弯曲根管预备的新技术, 进行根管预备时, 将镍钛器械在静止状态下插入根管至最大深度, 启动马达激活器械使其向根尖方向深入, 遇到阻力时即刻将器械从根管内取出并进行清理, 然后再次进入根管, 如此往复直至器械能够在静止状态下插入到达工作长度。

摘要

背景: 弯曲根管预备是根管治疗的难点, 临床上用于弯曲根管预备的主要方式是逐步深入技术, 但该技术预备弯曲根管时容易发生侧穿, 导致治疗失败。部分学者针对此种情况提出了使用触控启动技术进行预备, 目前国内外关于该技术结合不同机用镍钛器械对弯曲根管成形效果的影响研究较少。

目的: 观察不同类型热处理镍钛器械(WaveOneGold锉、Trunatomy锉、M3-Pro锉)分别结合逐步深入技术或触控启动技术预备树脂弯曲根管的成形效果。

方法: 将60个单弯树脂模拟根管采用随机数字表法分为6组, 每组10个样本: A1组采用逐步深入技术+WaveOneGold锉进行预备, A2组采用逐步深入技术+Trunatomy锉进行预备, A3组采用逐步深入技术+M3-Pro锉进行预备; B1组采用触控启动技术+WaveOneGold锉进行预备, B2组采用触控启动技术+Trunatomy锉进行预备, B3组采用触控启动技术+M3-Pro锉进行预备。预备完成后, 使用牙科手术显微镜获取预备前、后根管图像, 分析预备前后根管偏移量。

结果与结论: ①当使用WaveOneGold锉时, 采用触控启动技术预备后在距根尖1, 4, 7 mm处的根管偏移量小于采用逐步深入技术($P < 0.05$); 当使用Trunatomy锉时, 采用触控启动技术预备后在距根尖6, 8, 10 mm处的根管偏移量小于采用逐步深入技术($P < 0.05$); 当使用M3-Pro锉时, 采用触控启动技术预备后距根尖1, 2, 3 mm处的根管偏移量小于采用逐步深入技术($P < 0.05$); ②当采用逐步深入技术时, 使用Trunatomy锉预备后在距根尖1, 4, 5, 7 mm处的根管偏移量小于其余两种锉($P < 0.05$), 使用M3-Pro机用镍钛器械预备后在距根尖1, 2, 3, 6 mm处的根管偏移量大于其余两种锉($P < 0.05$); 当采用触控启动技术时, 使用Trunatomy锉预备后在距根尖2, 5, 6, 8, 9 mm处的根管偏移量小于其余两组锉($P < 0.05$), 使用M3-Pro锉预备后在距根尖1, 4, 5, 6, 7 mm处的根管偏移量大于其余两组锉($P < 0.05$); ③结果表明, 3种锉预备根管时都可产生根管偏移, 3种锉分别结合触控启动技术进行预备可减少根管部分位点的根管偏移量, Trunatomy锉较另2种锉在部分位点根管偏移量较少。

关键词: 根管预备; 触控启动技术; 逐步向下技术; 弯曲根管; 根管偏移; WaveOneGold锉; Trunatomy锉; M3-Pro锉; 工程化口腔材料

Comparison of effects of three machined nitinol instruments on preparing curved root canals using different methods

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Abstract

BACKGROUND: The preparation of curved root canals is a difficult point in root canal treatment, and the main way used in clinical preparation for curved root canals is to gradually deepen the technique, but this technique is prone to lateral penetration when preparing curved root canals, resulting in treatment failure. In view of this situation, some scholars have proposed the use of touch activation technology to prepare, but there are few studies on the influence of this technology combined with different mechanical nickel-titanium instruments on the forming effect of curved root canals at home and abroad.

OBJECTIVE: To observe the shaping effect of WaveOneGold, Trunatomy and M3-Pro mechanized nitinol device preparation root canal by using resin simulated root canal step-down technology and tactile controlled activation.

METHODS: 60 single-bending resin simulated root canals were divided into 6 groups ($n=10$) according to the random number table method according to the nitinol instrument used. The A1 group was prepared with step-down + WaveOneGold; the A2 group was prepared with step-down + Trunatomy, and the A3 group was prepared with step-down + M3-Pro. Tactile controlled activation + WaveOneGold was used for preparation in group B1; tactile controlled activation + Trunatomy was used for group B2, and tactile controlled activation + M3-Pro was used for preparation in group B3. After the preparation was completed, the pre-preparation and posterior root canal images are obtained using a dental surgical microscope. The root canal offset was analyzed before and after preparation.

RESULTS AND CONCLUSION: (1) When WaveOneGold was used, the root canal deviation at 1, 4, and 7 mm from the apex was smaller with the tactile controlled activation technique than with the step-down technique ($P < 0.05$); when Trunatomy was used, the root canal deviation at 6, 8, and 10 mm from the apex was smaller with the tactile controlled activation technique than with the step-down technique ($P < 0.05$); when M3-Pro was used, the root canal deviation at 1, 2, and 3 mm from the apex was smaller with the tactile controlled activation technique than with the step-down technique ($P < 0.05$). (2) When the step-down technique was used, the root canal deviation at 1, 4, 5, and 7 mm from the apex was smaller with the Trunatomy than with the other two files ($P < 0.05$), and the root canal deviation at 1, 2, 3, and 6 mm from the apex was larger with the M3-Pro machine-made nickel-titanium instrument than with the other two files ($P < 0.05$); when the tactile controlled activation technique was used, the root canal deviation at 2, 5, 6, 8, and 9 mm from the apex after preparation with the Trunatomy file was smaller than that of the other two groups ($P < 0.05$), and the root canal deviation at 1, 4, 5, 6, and 7 mm from the apex after preparation with the M3-Pro file was larger than that of the other two groups ($P < 0.05$). (3) The results showed that the three files could cause root canal deviation when preparing root canals. The three files combined with the tactile controlled activation technique could reduce the root canal deviation at some sites of the root canal. The root canal deviation at some sites of the Trunatomy file was less than that of the other two files.

Key words: root canal preparation; tactile controlled activation; step-down; curved root canal; root canal deviation; WaveOneGold; Trunatomy; M3-Pro; engineered dental material

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0 引言 Introduction

弯曲根管的预备一直是临床治疗中的难点^[1-2], 由于根管系统的复杂性以及镍钛器械的形变和记忆特性^[3-4], 易发生根管偏移等并发症, 导致治疗失败^[5]。目前临床上常用的预备方法主要为逐步深入技术, 在预备过程中为降低器械分离的风险通常会将器械在旋转状态下插入根管^[6], 然而, 镍钛锉在旋转状态进入根管时会使用者丧失手感, 难以辨别根管弯曲方向和弯曲角度^[5], 使器械难以顺从根管的弯曲走向, 从而导致根管穿孔。针对此种情况, 部分学者提出触控启动技术, 该技术可用于重度弯曲根管的预备, 并且取得良好效果^[7-8]。触控启动技术是将锉在静止状态下插入根管内弯曲点以下, 直至达到最大摩擦阻力且获得弯曲处根管的解剖结构和形态的触觉反馈之后开始启动马达预备, 可最大程度减小预备过程中镍钛锉的卡顿和扭转, 使用者容易掌握根管的弯曲走向, 减少根管发生穿孔的概率, 提高预备效率。但是目前针对触控启动技术预备弯曲根管效果的研究较少。此次实验拟采用不同类型的热处理镍钛器械分别结合逐步深入技术或触控启动技术预备树脂弯曲根管, 对不同镍钛器械以及不同预备技术进行评估, 从而为临床操作有针对性的选择提供参考。

1 材料和方法 Materials and methods

1.1 设计 材料学对比实验, 采取两独立样本 t 检验对实验数据进行统计学分析。

1.2 时间及地点 实验于 2024 年 1-7 月在十堰市人民医院口腔医学中心实验室完成。

1.3 材料 单弯树脂模拟根管模块 (Dentsply Maillefer, 瑞士); 不锈钢手动 K 锉 (Dentsply Maillefer, 瑞士); WaveOneGold 机用镍钛器械 (20/0.07、25/0.07, Dentsply Maillefer, 瑞士); Trunatomy 机用镍钛器械 (17/0.02、26/0.04, Dentsply Maillefer, 瑞士); M3-Pro 机用镍钛器械 (18/0.05、25/0.06, 益锐齿科材料有限公司, 中国); X-Smart Plus 根管马达 (Dentsply Maillefer, 瑞士); 格兰根管凝胶 (Dentsply, 瑞士); 红、蓝墨水 (上海英雄, 中国); 牙科手术显微镜 (S100, Zeiss, 德国)。

1.4 实验方法

1.4.1 实验分组 选择 60 个“J”型单弯树脂根管, 根尖孔直径 0.15 mm, 锥度 0.02, 全长 16 mm, 弯曲度 35°。每组 10 个样本: A1 组采用逐步深入技术 + WaveOneGold 锉进行预备, A2 组采用逐步深入技术 + Trunatomy 锉进行预备, A3 组采用逐步深入技术 + M3-Pro 锉进行预备; B1 组采用触控启动

技术 +WaveOneGold 锉进行预备, B2 组采用触控启动技术 + Trunatomy 锉进行预备, B3 组采用触控启动技术 +M3-Pro 锉进行预备。

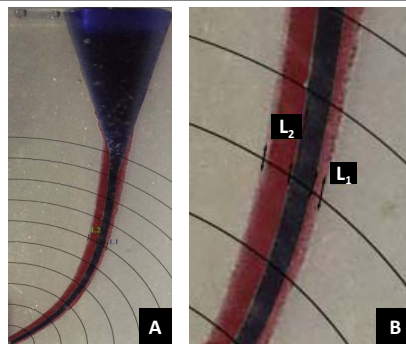
1.4.2 模拟根管预备前准备 将单弯树脂根管模块放入超声波清洗机中 20 min, 气枪吹干后, 置于烘干箱 (37 °C) 中 48 h 后取出, 采用 15# K 锉依次疏通模拟根管, 蒸馏水冲洗, 最后用吸潮纸尖干燥根管。将蓝色墨水通过注射器针头注入并充满根管内, 将模块固定在操作台上, 使牙科手术显微镜的物镜垂直于根管中轴, 放大倍数 10, 拍摄预备前的根管图像, 记录预备前的根管形态。使用高速手机对样本进行编号。

1.4.3 根管预备 逐步深入技术的原理是在冠部入口预备完成后, 先通过用手用锉和 G 钻完成根管入口的制备, 去除冠方阻碍, 然后行根尖区的预备。触控启动技术是将锉在静止状态下插入根管内弯曲点以下, 直至达到最大摩擦阻力且获得弯曲处根管的解剖结构和形态的触觉反馈之后开始启动马达预备。根管预备顺序按照每种镍钛锉制造商的说明进行。另外, 为了确保操作条件一致, 由操作人员仅用“啄动”的方式进行根管预备。在预备过程中, 辅助使用格兰根管润滑剂并以 15# K 锉疏通根管以防堵塞根尖孔。每种锉都经过 3 次幅度为 3.0-4.0 mm 上下提拉的“啄动”预备后, 操作人员用体积分数 75% 乙醇湿润的纱布清洁镍钛, 使用 5 mL 3%NaOCl 进行冲洗, 冲洗过程中使针尖位于距离根尖孔 2.0-3.0 mm 处。如此反复操作直至到达工作长度, 准备完成后, 用 5 mL 蒸馏水 + 超声波工作仪冲洗每个根管, 并用吸潮纸尖干燥根管。在牙科手术显微镜下观察器械的形变情况, 每组器械预备 5 个根管。所有根管治疗的准备工作均由同一操作人员进行。

1.4.4 预备后图像采集及处理 预备完成后, 在树脂根管中注入红色墨水, 操作人员在同一位置使用牙科手术显微镜拍照, 记录预备后的根管形态。利用 Adobe Photoshop 23.0.0 软件将预备前后的图像重合后, 以预备前的根尖为圆心, 半径从 1 mm 开始, 依次递增至 10 mm 作同心圆弧线, 选距根尖孔 1 mm 处为第一个观测点, 共选择 10 个观测点^[9]。采用 Image J 图像分析软件测量弯曲根管内外侧各位点的树脂去除量, 测量数据以 mm 为单位, 精度为 0.01 mm。使用每个位点从弯曲管内侧和外侧去除的树脂量之差绝对值来计算器械的根管偏移能力, 差值绝对值越小偏移量越小, 见图 1。所有数据测量 3 次后取平均值。

1.5 主要观察指标 各组根管偏移量。

1.6 统计学分析 所得结果采用 SPSS 26.0 统计软件进行统计学分析。各组数据均符合正态分布, 以 $\bar{x} \pm s$ 表示, 两组间比较采用独立样本 *t* 检验, 多组间比较采用单因素方差分析, $P < 0.05$ 为差异有显著性意义。检验水准 $\alpha=0.05$ 。该文统计



图注: 图 A 为预备前的根管图像; B 为图 A 中根管测量示意图放大, L_1 为根管弯曲外侧树脂去除量, L_2 为根管弯曲内侧树脂去除量, 根管偏移量记录为 L_1-L_2 。

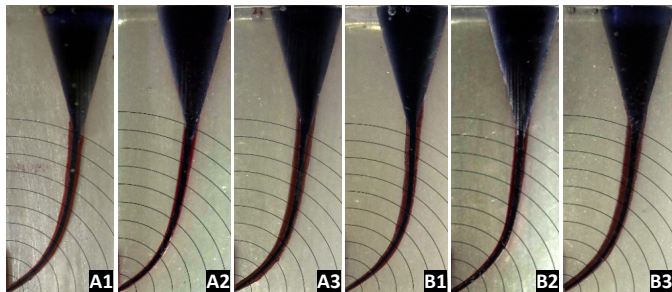
图 1 | 树脂根管预备前后根管影像重叠图片及根管偏移量测量方法示意图

Figure 1 | Overlapping images of root canal images before and after resin root canal preparation and schematic diagram of root canal deviation measurement method

学方法已经湖北医药学院生物统计学专家审核。

2 结果 Results

2.1 各组树脂根管预备前后重叠图像 见图 2。



图注: 图 A1 为 WaveOneGold 锉 + 逐步深入技术组; A2 为 Trunatomy 锉 + 逐步深入技术组; A3 为 M3-Pro 锉 + 逐步深入技术组; B1 为 WaveOneGold 锉 + 触控启动技术组; B2 为 Trunatomy 锉 + 触控启动技术组; B3 为 M3-Pro 锉 + 触控启动技术组。

图 2 | 各组树脂根管预备前后的重叠图像

Figure 2 | Pre-instrumentation and post-instrumentation superimposed images of each group

2.2 不同预备技术的根管偏移情况比较

2.2.1 WaveOneGold 锉结合不同预备技术的根管偏移情况 采用触控启动技术预备后在距根尖 1, 4, 7 mm 处的根管偏移量小于逐步深入技术 ($t_1=3.422$, $P_1=0.003$; $t_4=-2.817$, $P_4=0.011$; $t_7=-2.863$, $P_7=0.010$), 两种技术其余位点根管偏移量比较差异无显著性意义 ($P > 0.05$), 见图 3A。

2.2.2 Trunatomy 锉结合不同预备技术的根管偏移情况 采用触控启动技术预备后在距根尖 6, 8, 10 mm 处的根管偏移量小于逐步深入技术 ($t_6=-3.292$, $P_6=0.004$; $t_8=-3.571$, $P_8=0.002$; $t_{10}=6.289$, $P_{10} < 0.001$), 两种技术其余位点根管偏

移量比较差异无显著性意义 ($P > 0.05$), 见图 3B。

2.2.3 M3-Pro 锉结合不同预备技术的根管偏移情况 采用触控启动技术预备后在距根尖 1, 2, 3 mm 处的根管偏移量小于逐步深入技术 ($t_1=10.984, P_1 < 0.001; t_2=-3.290, P_2=0.004; t_3=-4.117, P_3=0.001$), 两种技术其余位点根管偏移量比较差异无显著性意义 ($P > 0.05$), 见图 3C。

2.3 不同镍钛器械的根管偏移情况比较

2.3.1 3 种镍钛器械采用逐步深入技术法预备的根管偏移情况 与其余两种锉比较, 使用 Trunatomy 锉预备后在距根尖 1, 4, 5, 7 mm 处的根管偏移量减小 ($P < 0.05$); 与其余两种锉比较, 使用 M3-Pro 锉预备后在距根尖 1, 2, 3, 6 mm 处的根管偏移量增加 ($P < 0.05$); 使用 M3-Pro 锉预备后在距根尖 4 mm 处的根管偏移量大于 Trunatomy 锉 ($P < 0.05$); 使用 WaveOneGold 锉预备后在距根尖 10 mm 处的根管偏移量小于 Trunatomy 锉 ($P < 0.05$), 3 种锉预备后在距根尖其余为点处的根管偏移量比较差异无显著性意义 ($P > 0.05$), 见表 1。

2.3.2 3 种镍钛系统采用触控启动技术法预备的根管偏移情况 与其余两种锉比较, 使用 Trunatomy 锉预备后在距根尖 2, 5, 6, 8, 9 mm 处的根管偏移量减小 ($P < 0.05$); 与其余两种锉比较, 使用 M3-Pro 锉预备后在距根尖 1, 4, 5, 6, 7 mm 处的根管偏移量增加 ($P < 0.05$); 3 种锉预备后在距根尖 3, 10 mm 处的根管偏移量比较差异无显著性意义 ($P > 0.05$), 见表 2。

3 讨论 Discussion

在根管治疗过程中, 预备时如果发生根管偏移则有可能导致治疗失败^[9-10]。理想的根管预备过程不仅要有效清理根管内的感染物质, 还要保持根管的原始形状^[11-12], 因此, 根管偏移是弯曲根管预备的重要评估指标。

此次研究分析比较了触控启动技术和逐步深入技术的成形效果, 结果表明, 与逐步深入技术相比, 3 种镍钛器械分别结合触控启动技术进行预备会导致部分位点的根管偏移量有所减少, 原因可能是: 在采用逐步深入技术法预备时镍钛锉与根管壁之间存在空隙, 加之器械具有一定的超弹性, 能够部分恢复原始的直线形态, 会造成根管内壁牙本质的不均匀切割, 从而导致根管偏移^[13-15]; 而触控启动技术技术仅在根管壁牙本质最大程度包绕器械时启动器械进行预备, 可以最大限度地减少接触根管壁, 对弯曲的根管进行适度扩大, 保持原始的根管形态^[16]。

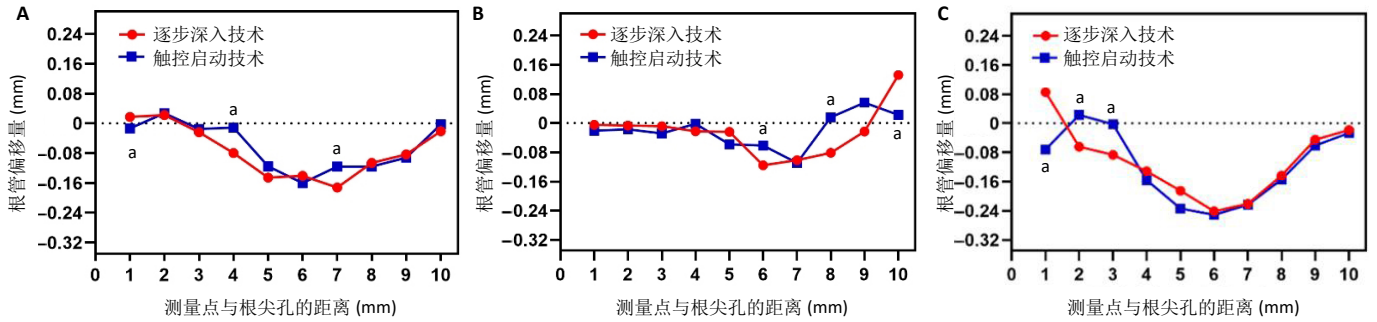
此次研究中不同镍钛系统结合同一种技术预备弯曲根管的成形效果显示, 无论采用何种预备方法, WaveOne Gold 锉在根管中下段的偏移量相比 Trunatomy 锉较大, 发生此种

现象的原因与 Trunatomy 锉本身的合金构成材料直径较细以及根管弯曲的起始点有关^[17-18], Trunatomy 锉的合金构成材料最大凹槽直径仅为 0.8 mm^[19], 而不是其他镍钛锉中常用的 1.2 mm^[20], 具有良好的柔韧性, 因而根管偏移的风险也相对较低^[21-23], 与 MORALES 等^[24]的实验一致。RIBEIRO 等^[25]进行的一项体外实验也表明, Trunatomy 锉相比 WaveOneGold 锉对根管具有更加良好的成形能力。

而 WaveOneGold 锉相比 M3-Pro 锉在根管中下段的偏移量较小, 分析原因可能与 WaveOneGold 锉运动方式为往复运动且锥度为变锥设计有关^[26-27], 不仅提升了器械的安全性能和切割效率^[28-30], 还具有更好的中心定位能力^[31-32], 可减少预备过程中的根尖偏移^[33-34]。另外, M3-Pro 锉的开口锉和通道锉主要以奥氏体为主, 可保持超弹性状态^[35-36], 因此刚性较大, 加之运动模式为连续旋转^[37], 可导致 WaveOneGold 锉在部分位点的根管偏移量相比 M3-Pro 锉较小, 与 YU 等^[38]的实验结果一致。

此次研究结果提示, 触控启动技术相比逐步深入技术可减少根管部分位点的偏移, 具有较大的临床应用前景, 但在临床中触控启动技术应用较少, 术者应充分在体外进行练习, 可先应用于根管较为弯曲的单根管牙齿进行预备, 以便观察根管治疗效果^[39]。Trunatomy 锉相比 WaveOneGold 锉和 M3-Pro 锉的成形效果更佳, 在治疗时 Trunatomy 锉对根尖段较狭窄的根管进行预备时可取得较好的效果^[40-41], 但对于根管较为粗大的牙齿切削效率较低, 建议辅助足够的化学冲洗才可更好地控制根管感染^[42-44]。M3-Pro 锉在根管中下段的根管偏移量相对较大, 但亦在安全范围之内, 可广泛应用于根管较为粗大且较直的牙齿治疗, 该锉为国产锉, 不仅价格较为实惠, 而且可取得较好的治疗效果; 而 WaveOneGold 锉较 Trunatomy 锉使用较为广泛, 中心定位能力较好且更容易获得, 在临床中可用于根管较细的弯曲根管的预备^[45-46], 但用于根管中下段的预备要谨慎小心, 以免发生穿孔^[47-49]。该实验也存在一定的局限性: 树脂模拟弯曲根管与人牙本质硬度不同^[50], 无法真实模拟根管牙本质硬度, 实验结果与临床实际情况可能存在些许误差, 未来仍需进一步改进。

综上所述, 无论采用何种方式对根管进行预备都会引起根管的偏移^[51-52], 使用时要避免发生侧壁穿孔的可能^[53]。在进行根管治疗时, 不同的预备技术以及不同类型镍钛器械的选择都可以影响根管预备效果, 在临床应用时应综合考量^[54-55]。采用热处理镍钛系统 WaveOneGold 锉、Trunatomy 锉以及 M3-Pro 锉分别结合触控启动技术法预备弯曲根管具有良好的成形效果, 但相关研究数据有限, 未来仍需要进一步的实验验证。



图注：图 A 为 WaveOneGold 锉结合不同技术预备弯曲根管的偏移情况；B 为 Trunatomy 锉结合不同技术预备弯曲根管的偏移情况；C 为 M3-Pro 锉结合不同技术预备弯曲根管的偏移情况。与逐步深入技术比较，^a*P* < 0.05。“-”表示根管向弯曲内侧偏移。

图 3 | 3 种镍钛器械分别结合不同技术预备弯曲根管的偏移情况

Figure 3 | Root canal deviation of different nickel-titanium instruments combined with different techniques to prepare curved root canals

表 1 | 3 种镍钛器械分别结合逐步深入技术预备弯曲根管后的根管偏移情况 ($\bar{x}\pm s, n=10, mm$)

镍钛系统	距根尖 1 mm 处	距根尖 2 mm 处	距根尖 3 mm 处	距根尖 4 mm 处	距根尖 5 mm 处
WaveOneGold 锉	0.017±0.024	0.023±0.043	-0.024±0.041	-0.080±0.068	-0.146±0.045
Trunatomy 锉	-0.005±0.015 ^a	-0.007±0.024	-0.008±0.022	-0.023±0.028 ^a	-0.024±0.043 ^a
M3-Pro 锉	0.086±0.027 ^{ab}	-0.064±0.075 ^{ab}	-0.086±0.058 ^{ab}	-0.132±0.073 ^b	-0.185±0.062 ^b
<i>F</i> 值	43.351	7.259	9.270	8.378	27.526
<i>P</i> 值	< 0.001	0.003	0.001	0.001	< 0.001
镍钛系统	距根尖 6 mm 处	距根尖 7 mm 处	距根尖 8 mm 处	距根尖 9 mm 处	距根尖 10 mm 处
WaveOneGold 锉	-0.140±0.058	-0.172±0.054	-0.106±0.055	-0.083±0.015	-0.021±0.036
Trunatomy 锉	-0.116±0.045	-0.102±0.023 ^a	-0.082±0.061	-0.023±0.063	0.132±0.026 ^a
M3-Pro 锉	-0.242±0.048 ^{ab}	-0.221±0.087 ^b	-0.144±0.074 ^b	-0.045±0.092	-0.018±0.051 ^b
<i>F</i> 值	17.283	9.802	2.372	2.200	50.215
<i>P</i> 值	< 0.001	0.001	0.112	0.130	< 0.001

表注：“-”表示根管向弯曲内侧偏移。与 WaveOneGold 锉比较，^a*P* < 0.05；与 Trunatomy 锉比较，^b*P* < 0.05。

表 2 | 3 种镍钛器械分别结合触控启动技术预备弯曲根管后的根管偏移情况 ($\bar{x}\pm s, n=10, mm$)

镍钛系统	距根尖 1 mm 处	距根尖 2 mm 处	距根尖 3 mm 处	距根尖 4 mm 处	距根尖 5 mm 处
WaveOneGold 锉	-0.014±0.016	0.027±0.029	-0.015±0.045	-0.011±0.036	-0.115±0.027
Trunatomy 锉	-0.021±0.033	-0.017±0.026 ^a	-0.029±0.031	-0.002±0.034	-0.058±0.046 ^a
M3-Pro 锉	-0.072±0.036 ^{ab}	0.023±0.037 ^b	-0.002±0.028	-0.156±0.086 ^{ab}	-0.234±0.074 ^{ab}
<i>F</i> 值	11.339	6.098	1.352	22.665	29.097
<i>P</i> 值	< 0.001	0.007	0.276	< 0.001	< 0.001
镍钛系统	距根尖 6 mm 处	距根尖 7 mm 处	距根尖 8 mm 处	距根尖 9 mm 处	距根尖 10 mm 处
WaveOneGold 锉	-0.160±0.037	-0.116±0.030	-0.116±0.049	-0.092±0.076	-0.002±0.086
Trunatomy 锉	-0.062±0.027 ^a	-0.109±0.029	0.016±0.061 ^a	0.056±0.073 ^a	0.023±0.048
M3-Pro 锉	-0.251±0.082 ^{ab}	-0.224±0.070 ^{ab}	-0.154±0.110 ^b	-0.061±0.074 ^b	-0.026±0.103
<i>F</i> 值	30.452	18.458	13.126	10.984	0.880
<i>P</i> 值	< 0.001	< 0.001	< 0.001	< 0.001	0.426

表注：“-”表示根管向弯曲内侧偏移。与 WaveOneGold 锉比较，^a*P* < 0.05；与 Trunatomy 锉比较，^b*P* < 0.05。

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