A comparison of Profile, Hero 642, and K3 instrumentation systems in teeth using digital imaging analysis

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Objective. To evaluate the changes in cross-sectional area morphology of curved canals after instrumentation with Profile®, Hero 642®, and K3® using digital imaging analysis.

Study design. Thirty mesial mandibular curved canals were used (25-40°). The molars were embedded in resin and the roots were sectioned transversely at three levels: apical, middle, and coronal. The canals were randomly distributed into 3 groups for instrumentation using Profile .04 and .06, Hero 642, and K3. The pre- and postinstrumentation sections were digitized and areas corresponding to the canals were measured with image-processing software.

Results. Hero eliminated significantly more dentine than K3 and Profile in all 3 sections (P < .01, ANOVA test), with no differences observed between the latter 2 systems (P > .05, Student-Newman-Keuls test). All 3 systems yielded a rounded canal morphology in the coronal, middle, and apical thirds.

Conclusion. Hero rotary instruments produced more changes in cross-sectional area of the root canal.


Root canal instrumentation is performed to achieve a progressively conical morphology from the entry orifice to the apical constriction, thus allowing adequate cleaning and disinfection of the complex root canal system with maximum preservation of its initial morphology. Finely curved root canals are of prime importance to the endodontist but instrumentation in curved canals can often produce apical transportation, apical zipping, and an hour-glass shape. It is not necessary to remove a large amount of dentine to achieve effective access to the root canal system. A conservative morphology is required at the apical foramen, with a small instrumentation end-diameter, and a deep and complete form at the junction of the middle and apical thirds. If the middle third of the canal is not sufficiently widened, the irrigating solutions will be unable to reach the apical third or lateral canals. On the other hand, there is risk of canal perforation when the coronal third is excessively widened with Gates drills (Dentsply-Maillefer, Ballaigues, Switzerland). Likewise, a conical funnel-like shape is required to facilitate conventional canal sealing, with a small apical and large coronal diameter.

The crown-down technique was presented by Marshall and Pappin in 1980 in association with a new series of engine-driven instruments with progressive serial conicity specifications. It offers better instrumentation performance compared with step-back techniques using standardized manual instruments.

Knowledge of the optimum speed and torque performance of mechanical rotary instruments and training in their use are necessary to avoid instrument deformation and fracture.

Different experimental models have been developed to assess the morphological changes in root canal anatomy. In this context, it has recently been shown that variations in canal geometry exert a greater influence on changes during instrumentation than the actual techniques employed.

The objective of this study was to evaluate, using digital imaging analysis, changes in cross-sectional area morphology of curved canals after instrumentation with 3 mechanical rotary systems: Profile®, .04 and .06 (Dentsply-Maillefer, Ballaigues, Switzerland), Hero 642® (MicroMega, Besançon, France), and K3® (Kerr Corporation, Herts, UK).

MATERIALS AND METHODS

Selection of teeth

Thirty-four mesial canals in nonrestored human mandibular molars with an intact crown were stored in physiological saline solution until use. Tooth selection criteria were the following: fully formed apices, similar root lengths from furcation to apex (10 ± 1 mm), and the presence of 2 separate canals in the mesial root (as determined by canal measurement radiography).

The occlusal surfaces of the molars were leveled

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using a diamond disc to provide a reference point for the instrumentation. Chamber access was achieved with a tapered diamond instrument (number 846-012 FG) (Komet, Brasseler, GmbH & Co, Lemgo, Germany) and Zekrya-Endo bur (Dentsply-Maillefer, Ballaigues, Switzerland), placing a size 8 or 10 Flexofile (Dentsply-Maillefer) in the canal until it was visible at 1 mm short of the apical foramen. Another x-ray image was then obtained for verification purposes and for determining the curvature of the mesial canals, based on the Schneider technique. The curvature of the selected canals was between 25 and 40° in all cases.

Specimens were prepared using a technique described by Bramante and Berbert. Molars were embedded up to the cementoenamel junction in cold-polymerizing transparent acrylic resin (Inplex, Tecmicro, s.a., Parma, Italy) with their long-axis in vertical orientation using dismountable stainless steel molds to facilitate removal. After mold removal, marks were made in the resin block for subsequent segmentation. The following measurements were defined: (1) 2 mm from the apical foramen [A]; (2) at the middle third of the root [M]; and (3) at the coronal third of the root [C]. Transversal sections were made with an Accutom 50 (Struers, Copenhagen, Denmark), using a disc of 100 to 200 μm thickness. The sections were then labeled and immersed in an ultrasound bath with sodium hypochlorite in order to eliminate any remaining organic tissue from the canals. After drying, the canal lumen at the coronal surface of the sections was filled with Utilite red wax (Hygenic Corporation, Akron, Ohio) to secure improved contour definition for subsequent digital processing.

The sections were true-size digitized using a HP ScanJet 7450C scanner (Hewlett-Packard, Madrid, Spain) with a resolution of 1200 ppi to facilitate the measurement process. The preoperative images were stored in *tiff format, and the areas of the different canal sections were measured in pixels by 2 investigators using Adobe Photoshop version 6.0 (Adobe Systems Incorporated, San Jose, Calif).

### Canal preparation

The sections were reassembled after completely removing the wax from the canal lumen, using a number 10 Flexofile. The specimens were randomly distributed into 3 groups, assigning 10 canals to each mechanical instrumentation system: Profile, Hero, K3. All canals were instrumented by the operator according to the established technique (Table 1), using a TriAuto ZX handpiece (J. Morita Europe, GmbH & Co, Germany) in manual mode, with a speed of 280 ± 50 rpm and a torque predetermined by the manufacturer for that speed range. The operator was trained in instrumentation with mechanical rotary systems. After each instrument size, irrigation was performed with 2 mL of 2.5% sodium hypochlorite. In all 3 systems, the reamers were replaced after instrumentation of 5 root canals.

After completing instrumentation, the specimens were dismounted and wax was again introduced into the canal lumen. The sections were digitized and measured under the same conditions as during the preoperative phase. The pre- and postinstrumentation measurements were converted to the metric system, calculating the number of pixels corresponding to 1 mm²; at a resolution of 1200 ppi, 1 mm² is equivalent to (47 pixels)² = 2209 pixels. The following parameters were evaluated: initial measurements of canal surface area and the amount of dentine removed (in terms of area) by each instrumentation system, expressed as the difference between the pre- and postinstrumentation areas. The morphological changes were in turn evaluated from the pre- and postoperative images.

The mean initial area of the canal and the mean area of dentine removed were calculated for each instrumentation system. Global comparisons were made by 1-way analysis of variance (ANOVA), and the Student-Newman-Keuls test was used for multiple comparisons. A P-value of .05 was regarded as significant.

### RESULTS

The final sample comprised 30 canals. Four instruments were fractured during the study and the canals were replaced.

The initial canal shape is shown in Table 2. After instrumentation, rounded forms were obtained in the coronal, middle, and apical thirds of all canals. Table 3 shows the results corresponding to the mean initial canal areas in all 3 sections. The specimens studied differed significantly in the initial coronal area (P = .043). Nevertheless, there were no differences among the 3 instrumentation systems. At the middle- and api-

<table>
<thead>
<tr>
<th>Instruments</th>
<th>Coronal third</th>
<th>Middle third</th>
<th>Apical third</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st phase</td>
<td>06-30</td>
<td>04-30</td>
<td>04-25</td>
</tr>
<tr>
<td></td>
<td>06-25</td>
<td>04-25</td>
<td>04-30</td>
</tr>
<tr>
<td></td>
<td>06-20</td>
<td>04-20</td>
<td>04-25</td>
</tr>
<tr>
<td>2nd phase</td>
<td>06-25</td>
<td>04-30</td>
<td>04-25</td>
</tr>
<tr>
<td></td>
<td>06-20</td>
<td>04-20</td>
<td>04-25</td>
</tr>
<tr>
<td>3rd phase</td>
<td>06-25</td>
<td>04-30</td>
<td>04-25</td>
</tr>
</tbody>
</table>
cal-third levels, no statistically significant differences in canal area were observed ($P = .354$ and $P = .103$, respectively).

Results for the amount of dentine removed are shown in Table 4. The Hero 642 mechanical system removed significantly more dentine than Profile and K3 in all 3 canal sections (C: $P = .003$, M: $P = .001$, A: $P = .001$); no significant differences were observed between Profile and K3 (C: $P = .160$, M: $P = .192$, A: $P = .398$).

### DISCUSSION

The new series of engine-driven variable-tapered instruments are claimed to improve root canal instrumentation, yielding predictable apical resistance with small apical diameters and controlled coronal and middle widening, thus ensuring increased confidence in improved conical canal filling.\(^4\)

We agree with Machtou and Martin\(^{18}\) that only gentle pressure should be applied to Profile instruments and the working time limited to 3-4 seconds in order to reduce deformation and fracture risks. As reported above, 4 instruments fractured in the present study: 2 Profile.04, 1 Hero 642 with 4% conicity, and 1 K3 with the same conicity. We are also in agreement with Kobayasi et al\(^{19}\) and Yared et al\(^8\) that fine instruments used in strongly curved canals fracture more easily than instruments of greater diameter, as a result of the increased torque applied to the instrument.

All 3 systems allowed effective instrumentation of canals with curvatures of 25° or more. However, differences were observed in the amount of dentine removed from the canals during instrumentation, with greater losses using Hero 642 compared with Profile .04 and .06 and K3 instruments (Table 4). This seems reasonable, considering that the Hero instrument has a helicoid section (triple helix) with a positive sectioning angle, making it more effective in eliminating dentine from within the canal than the other 2 instrument types, which have more restricted sections due to the presence of radial lands. No statistically significant differences were observed between Profile and K3 in terms of the amount of dentine removed in the 3 canal sections.

Final canal morphology was rounded, with minor variations, in the middle and apical thirds. Furthermore, the amount of dentine removed and the deformities observed were negligible or nonexistent in the apical third, consistent with the observations of Jardine and Gulabivala.\(^{20}\)

Earlier studies\(^{20,21}\) that compared the efficacy of manual and mechanical techniques reported no significant differences in canal wall centering or position. In a recent study, Peters et al\(^{15}\) reported that final canal morphology after instrumentation appears to depend more on the initial canal anatomy than on the instrumentation techniques used. They therefore recommended taking canal anatomical details into account before instrumentation. In our study, the initial canal areas were comparable at middle and apical third level, whereas the coronal third showed statistically significant differences (Table 3). Thus, the canals instrumented with the Profile system were smaller at coronal third ($0.179 \pm 0.074$) than those instrumented with the K3 ($0.232 \pm 0.058$) and Hero ($0.276 \pm 0.106$) systems, with significant differences between the Profile and Hero instruments.

In our view, the greater removal of root dentine obtained with the Hero is desirable in cases of frank infection of the root canal, because it facilitates in-depth penetration by irrigating solutions, improving the disinfection and eliminating more infected dentinal tissue. During vital pulpectomy, when there is no root canal infection present, however, it is not necessary to remove a large amount of dentin, with the associated risk of structural weakening of the canal wall. Therefore, the other 2 systems would be indicated for pulpectomies.

In general terms, manual systems limit the instrumentation of curved and narrow canals. In contrast, mechanized rotary techniques improve and facilitate canal instrumentation, reducing operating time with individualized sequences developed by our group, and ensuring less deformity at apical level.

### CONCLUSIONS

Rotary Hero instruments with conicities of 4% and 6% remove more dentine from the root canal compared with Profile and K3 series instruments with identical conicity specifications.
Table III. Mean initial canal surface areas (mm²)

<table>
<thead>
<tr>
<th>Instrumentation system</th>
<th>Coronal $\bar{x}$ (s)</th>
<th>Middle $\bar{x}$ (s)</th>
<th>Apical $\bar{x}$ (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profile</td>
<td>0.179 (0.074)</td>
<td>0.117 (0.072)</td>
<td>0.051 (0.033)</td>
</tr>
<tr>
<td>K3</td>
<td>0.232 (0.058)</td>
<td>0.157 (0.080)</td>
<td>0.086 (0.042)</td>
</tr>
<tr>
<td>Hero</td>
<td>0.276 (0.106)</td>
<td>0.157 (0.054)</td>
<td>0.087 (0.047)</td>
</tr>
</tbody>
</table>

Global $F_{\text{exp}}(2, 27 \text{ df}) = 3.554, P = .043$  

$\bar{x} =$ arithmetic mean; $s =$ standard deviation; df = degrees of freedom.
Values joined by vertical lines were not significantly different.

Table IV. Mean area of dentine removed, expressed as the difference between the pre- and postinstrumentation areas (mm²)

<table>
<thead>
<tr>
<th>Instrumentation system</th>
<th>Coronal $\bar{x}$ (s)</th>
<th>Middle $\bar{x}$ (s)</th>
<th>Apical $\bar{x}$ (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>K3</td>
<td>0.203 (0.055)</td>
<td>0.122 (0.040)</td>
<td>0.045 (0.020)</td>
</tr>
<tr>
<td>Profile</td>
<td>0.252 (0.063)</td>
<td>0.161 (0.041)</td>
<td>0.065 (0.030)</td>
</tr>
<tr>
<td>Hero</td>
<td>0.323 (0.088)</td>
<td>0.248 (0.096)</td>
<td>0.135 (0.079)</td>
</tr>
</tbody>
</table>

Global $F_{\text{exp}}(2, 27 \text{ df}) = 7.422, P = .003$  

$\bar{x} =$ arithmetic mean; $s =$ standard deviation; df = degrees of freedom.
Values joined by vertical lines were not significantly different.

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REFERENCES


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