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Effectiveness of HERO 642 versus Hedström files for removing gutta-percha fillings in curved root canals: an *ex vivo* study

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Abstract

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Aim To compare the effectiveness of gutta-percha removal and the maintenance of canal anatomy when using the HERO 642 system or Hedström files (H-files) in mandibular molar teeth.

Methodology The root canals of 40 mandibular molar teeth were instrumented using H-files and filled with gutta-percha and sealer. After 1 year in storage, the roots were sectioned horizontally to provide apical, middle and coronal root thirds. Sections were photographed, and an individual muffle was produced for each tooth. Teeth were randomly divided into four groups ($n = 10$) and the gutta-percha removed using either the HERO 642 system or H-files, with or without solvent. Digital images of the root canals were then re-taken. Root thirds were inspected for lateral perforations, and the percentage of the residual canal filling was determined on postoperative images. Transportation and centring ratio were calculated using preoperative and postoperative images of the cross-sections of root thirds.

Results H-files groups were associated with less filling material than the HERO 642 system (H-files–HERO 642 $P = 0.056$, H-files–HERO 642+solvent $P = 0.041$, H-files + solvent–HERO 642 $P = 0.018$, H-files + solvent–HERO 642 + solvent $P = 0.016$). The percentage of residual filling material was similar in the apical thirds, and the contribution of solvent to canal debridement was not statistically significant ($P > 0.05$). Perforation occurred mesiobuccally in 48% of specimens in the apical sections of mesial roots. There were no significant differences for centring ratio, transportation and perforation rate between groups.

Conclusions H-files left less gutta-percha overall; however, there was no difference in the apical third. The effect of solvent was not remarkable. Both instrument systems created a large number of perforations.

Keywords: centring ratio, Hedström files, HERO 642, mandibular molar teeth, retreatment.

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Introduction

Nonsurgical root canal retreatment requires complete removal of previous filling materials to enable disinfection and the shaping of the canal system (Stabholz & Friedman 1988, Friedman *et al.* 1990). However, gutta-percha root fillings cannot be removed completely (Bramante & Betti 2000, Masiero & Barletta 2005), especially from the apical third of the root canal (Masiero & Barletta 2005, Gergi & Sabbagh 2007).

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Hand files, ultrasonic systems, solvents, heat transferring instruments, rotary files, lasers and combinations of these methods have been used in an attempt to remove root fillings (Friedman *et al.* 1990, Zakariasen *et al.* 1990, Baratto Filho *et al.* 2002). Amongst these instruments, nickel-titanium (Ni-Ti) rotary instruments have been found to be practical and effective (Ferreira *et al.* 2001, Baratto Filho *et al.* 2002). For instance, K3 and ProTaper provided cleaner root canal walls than hand instrumentation in incisor teeth (de Carvalho Maciel & Zaccaro Scelza 2006). Specific rotary files such as R-Endo, ProTaper Universal and Mtwo-Retreatment have been used to remove root fillings, but their efficacy was not found to be superior than hand instrumentation (Gergi & Sabbagh 2007, Taşdemir *et al.* 2008). HERO 642 (MicroMega, Besançon, France) has been used in retreatment of incisor teeth (de Carvalho Maciel & Zaccaro Scelza 2006) and a number of studies have demonstrated its effectiveness and safety for root canal shaping. However, its canal filling removal efficacy has not been explored in mandibular molar teeth.

The effectiveness of gutta-percha removal depends on anatomic factors: shape of root canal section, degree of root canal curvature and previous shaping and filling (Wilcox & van Surksum 1991, Baratto Filho *et al.* 2002). The present study was carried out to compare the effectiveness of removing canal fillings along with the maintenance of canal anatomy of the HERO 642 system versus Hedström-files (H-files) in mandibular molar teeth.

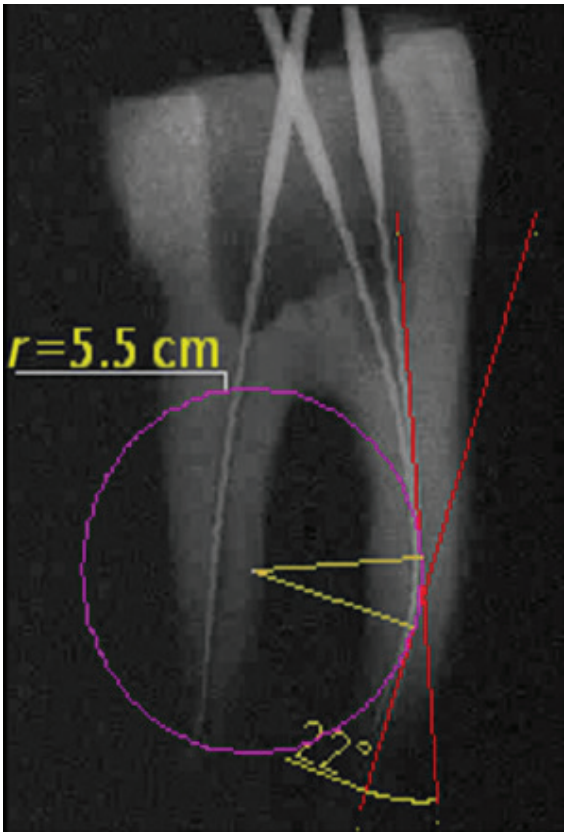

Figure 1 A moderately curved mesial root canal having a curvature angle less than 25° and a curvature radius greater than 4 cm was demonstrated using AutoCAD 2000 software (Autodesk, San Rafael, CA, USA).

Materials and methods

Approximately 100 freshly extracted human teeth were collected from the Department of Oral Surgery, University of Ege, İzmir, Türkiye, from patients who had signed the appropriate informed consent form approved by the university institutional review board. From this pool of teeth, human mandibular molars with two separate roots, two mesial and one distal canal were selected. Root canals with a radius of curvature greater than 4 cm and an angle of curvature less than 25° were included (Fig. 1) (Pruett *et al.* 1997).

Overall, 52 teeth that fulfilled the criteria were selected and then embedded in an acrylic resin block to the level of the cemento–enamel junction. The root canals were instrumented using a step-back technique. The master apical file size was 25 or 30 in all mesial canals, and 40 or 45 in distal canals. Two millilitres of 2.5% sodium hypochlorite was used to irrigate the canal after each instrument. The step-back phase of canal preparation was completed with three sequentially larger H-files (Dentsply Maillefer, Ballaigues, Switzerland).

Canals were filled with gutta-percha and Diaket sealer (3M, ESPE, Seefeld, Germany) using the cold lateral compaction technique, and the teeth were restored with Cavit-G (3M, ESPE). After 1-year storage in 100% humidity at 37 °C, the roots of the teeth were sectioned horizontally. During sectioning, five teeth were lost because of misaligned cuts and loss of embedding material. After sectioning, seven teeth were utilized for a pilot study and the remaining 40 teeth were used in the main study. A diamond-wafering blade 0.5 mm thick connected to a saw (Isomet 1000 Precision Saw, Buehler, IL, USA) was used for sectioning the roots. The apical first 2 mm was considered as the apical section. The centre 2 mm of the middle third and the centre 2 mm of the coronal third were categorized as the middle and coronal sections. Sections were attached

vertically on a stand with a black background. The camera (FinePix S7000, Fujifilm Co., Tokyo, Japan) was adjusted to super-macro function, and its objective was centred and fixed 1 cm from the sample surface. Each section was photographed at 19 × magnification. All the sections were checked for canal filling quality that is based on good adaptation on the canal walls without any voids, and subsequently sections were reassembled using a weak glue. To maintain the integrity of the root canals during retreatment, an individual muffle was created using plastic caskets and a putty silicone impression material (Zetaplus, Zhermack, Badia Palestine, Italy; Fig. 2). Next, 40 samples were randomly assigned into four groups of 10 teeth each. In each group, one of the following techniques was used to remove the root canal filling.

Group 1: H-files

To reach the working length (WL), Hedström files size 30 and 25 were used in mesial canals, and size 25 files was used at the WL. Root canals were irrigated copiously with distilled water between the use of each file. Root canals were re-instrumented using anti-curvature filing until a size 35 or 40 H-file was loose at the WL (Mesial canals, previously instrumented to size 25 at WL, were enlarged to size 40). The master apical file was size 50 in distal canals after re-instrumentation, and step-back phase was completed using three sequentially larger H-files in each canal.

Group 2: H-files + solvent

The same instrumentation and irrigation methods from the first group were used. Gutta-percha was softened using 0.5 mL of ethyl ether–chloroform mixture (Copalite; Cooley and Cooley, Houston, TX, USA). When the WL was reached, using of solvent was discontinued.

Group 3: HERO 642

Gutta-percha was removed using 0.06 taper sizes 30 and 25 instruments. After irrigation, HERO 642 instruments were used in an order according to the manufacturer instructions for working with canals within an average degree of curvature. When no gutta-percha remnants were observed during irrigation, instrumentation was finalized using 0.02 taper size 35 or 40 instruments at WL.

In distal canals, an instrument order suggested by the manufacturer for 'easy' canals was applied; size 35, 40 and 45 instruments with 0.02 taper were used at WL.

Group 4: HERO 642 + solvent

The same instrumentation and irrigation methods as in the third group were used; additionally, 0.5 mL of solvent was used before each rotary file. When the WL was reached, use of solvent was discontinued. During the study, each instrument was used no more than thrice.

Upon the completion of canal preparation, digital photographs of each section were taken as described before. The images were transferred to a computer, and the borders of the residual canal filling was traced using software (LUCIA Version 4.21; Laboratory Imaging Ltd, Prague, Czech Republic) and the percentage of the residual canal filling was determined for each root third of each canal. As it is known that both gutta-percha and sealer remnants may compromise the success of the retreatment, it was planned to evaluate sealer and gutta-percha residues together. For this purpose, a polyketone-based sealer, which can be easily removed using solvents (Erdemir *et al.* 2003), was chosen. During the evaluations, no attempt was made to distinguish between the sealer and gutta-percha residues.

Apical sections were inspected for lateral perforation, and further investigated for transportation and centring ratio using image analysis software (Motic Images Plus 2.0 ML; Motic China Group Co., Ltd, Xiamen, People's Republic of China). When calculating the residual canal filling amounts, and whilst measuring transportations, mesiobuccal and mesiolingual canals were horizontally separated in apical sections if canals merged apically.

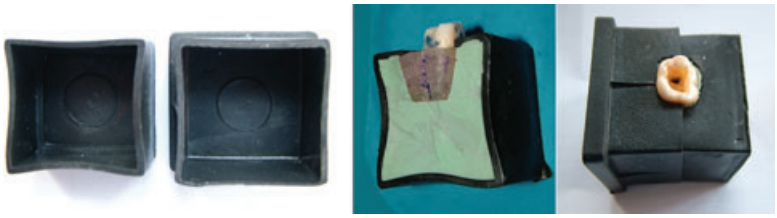

Figure 2 Plastic caskets with dimensions of 4 cm × 4 cm × 2 cm. and their tightly fitting counter-pieces were used as muffles. Acrylic blocks were embedded and supported using a silicone impression material.

Apical centring ability of HERO 642 and H-files was explored by calculating the 'centring ratio' (Calhoun & Montgomery 1988) (Fig. 3), and the distance of transportation was determined by measuring the greatest length between the edge of the retreated canal and the corresponding edge of the previously instrumented canal.

Friedman and Wilcoxon Signed Ranks tests were used to compare the amount of the residual canal fillings, and lateral apical perforation incidences were assessed using chi-square test, P values less than 0.05 were considered as significant.

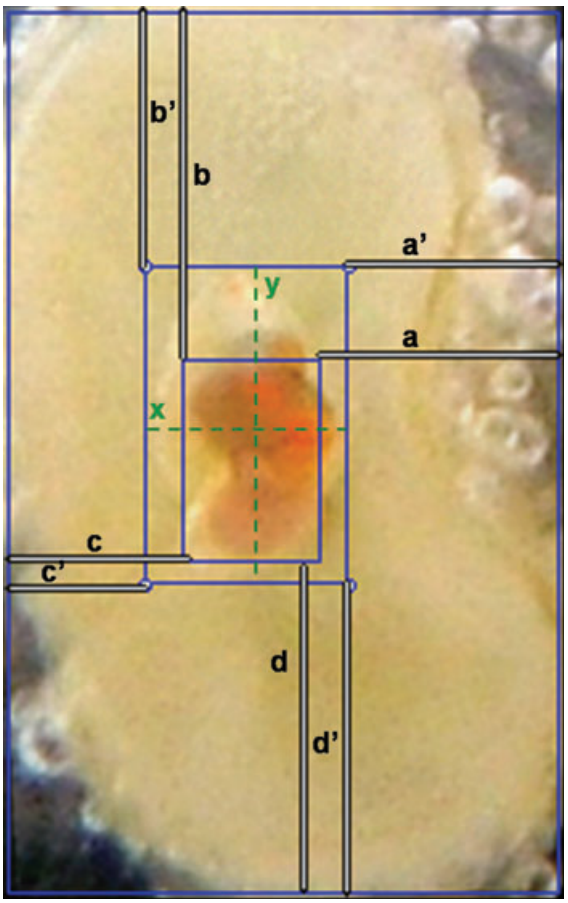

Figure 3 Apical section of a mesial root from HERO 642 group. Images taken before and after retreatment were superimposed. Centring ratio was calculated by the formula for mesiodistal direction: (a–a′) – (c–c′)/x, (a–a′) represents the greatest deviation of post-retreatment canal form in one direction, and (c–c′) is the movement in the opposite direction; x is the retreated canal's diameter mesiodistally. Buccolingual centring ratio was calculated in the same manner: (b–b′) – (d–d′)/y.

Results

Residual gutta-percha

The percentage of the residual root canal filling material for each group is demonstrated in Fig. 4. Canal filling remnants were least in the H-files + solvent group, but there was no statistically significant difference between two hand file groups (P = 0.639). There was significantly less canal filling in the hand file groups than in the HERO 642 groups (H-files and HERO 642 P = 0.056, H-files and HERO 642 + solvent P = 0.041, H-files + solvent and HERO 642 P = 0.018, H-files + solvent and HERO 642 + solvent P = 0.016).

When the root thirds of groups were compared, statistically significant difference was present only for the middle thirds, H-files and H-files + solvent groups showed significantly less residual filling than HERO 642 (P = 0.028, 0.013) and HERO 642 + solvent groups (P = 0.034, 0.034; Fig. 5).

Friedman test revealed no significant differences in the residual canal filling of the mesiolingual and distal canals root thirds. However, in the mesiobuccal canals, there was significantly more residual filling material in the apical third than in the coronal third in the hand files group (P = 0.022), and in HERO 642 + solvent group, the apical third (P = 0.009) and the middle third (P = 0.022) of the mesiobuccal canal retained more residual filling material than coronal third (Table 1).

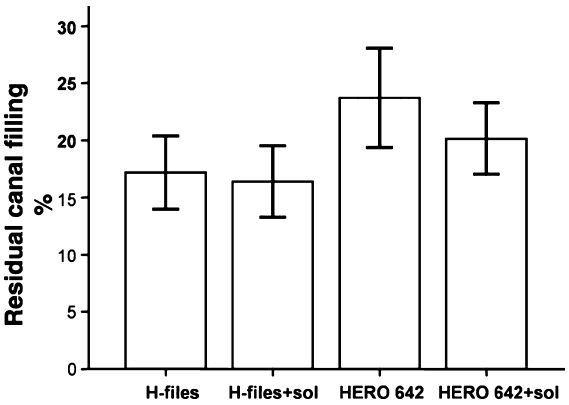

Figure 4 The percentage of entire residual root canal filling material in each group (error bars represent the 95% confidence interval). H-files and HERO 642 P = 0.056, H-files and HERO 642 + solvent *P = 0.041, H-files + solvent and HERO 642 *P = 0.018, H-files + solvent and HERO 642 + solvent *P = 0.016. *Wilcoxon Signed-Rank test revealed a significant difference amongst the groups, $P < 0.05$.

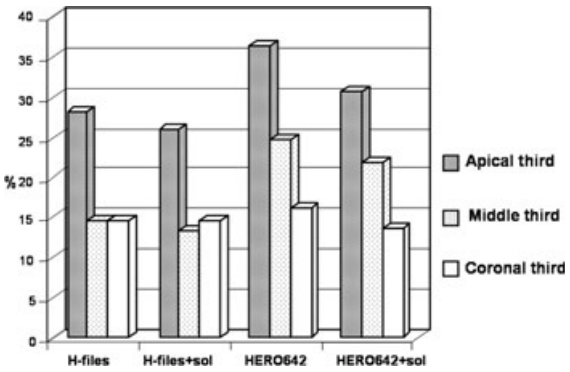

Figure 5 Residual canal filling in root thirds.

Centring ratio and perforations

Mesiodistal mean centring ratio of mesial apical root thirds was equal to 0.25 ± 0.23 mm for H-files, 0.23 ± 0.26 mm for H-files + solvent, 0.31 ± 0.29 mm for HERO 642 and 0.25 ± 0.13 mm for HERO 642 + solvent group. Mean distance of apical transportation was shown in Table 2, and its direction and rate are shown in Table 3. There was no statistically significant difference in centring ratio and also in transportation values between the groups.

Following the removal of the canal filling and re-instrumentation, lateral perforation occurred mesiobuccally in apical sections of mesial roots (Fig. 6). There was no significant difference between the groups for perforation rate; 26.3% in H-files, 21.1% in H-files + solvent, 36.8% in HERO 642, 15.8% in HERO 642 + solvent (48% total perforation rate). No hand file or HERO 642 file breakage occurred.

Discussion

Residual gutta-percha

Regardless of the technique, more residual canal filling material remained in the apical third than in the middle and coronal thirds as has been reported previously (Ferreira *et al.* 2001, Masiero & Barletta 2005, Gergi & Sabbagh 2007). In a recent study, it was demonstrated that R-Endo, which is manufactured particularly for retreatment, and HERO 642 systems were not more effective than hand instruments in single-rooted teeth for gutta-percha removal (de Carvalho Maciel & Zaccaro Scelza 2006, Taşdemir *et al.* 2008). In addition, studies that used different rotary systems in curved (Schirrmeister *et al.* 2006) or straight canals

Table 1 Mean area fraction of root canal cross-section covered by root canal filling remnants after retreatment

Root thirds	H-files	H-files + solvent	HERO 642	HERO 642 + solvent
Apical Mb	48.19 ± 38.20*	36.73 ± 34.19	42.04 ± 50.07	35.63 ± 24.34[a]
Apical Ml	16.10 ± 20.22	27.28 ± 32.11	36.47 ± 44.99	25.92 ± 9.37
Apical D	20.00 ± 23.36	14.26 ± 16.70	30.46 ± 34.62	30.55 ± 41.36
Middle Mb	15.37 ± 12.03	11.97 ± 16.57	29.08 ± 18.85	24.43 ± 15.80[b]
Middle Ml	14.19 ± 17.91	13.04 ± 16.06	20.50 ± 20.42	23.27 ± 15.95
Middle D	12.77 ± 12.66	14.84 ± 13.85	24.81 ± 16.12	16.05 ± 12.47
Coronal Mb	14.73 ± 11.79*	17.12 ± 19.97	14.22 ± 19.94	14.09 ± 12.70[a,b]
Coronal Ml	14.32 ± 13.76	18.98 ± 14.60	12.49 ± 14.82	15.66 ± 19.28
Coronal D	15.22 ± 14.60	7.79 ± 10.31	22.19 ± 18.42	11.55 ± 15.68

Mesiolingual (Ml), mesiobuccal (Mb) and distal (D) canals were evaluated in their apical, middle and coronal thirds.
*,[a,b]Significant difference at values labelled with the same letters ($P < 0.05$).

Table 2 Mean length in mesiodistal and buccolingual direction of apical transportation in millimeters

	Mesiobuccal transportation (mean ± SD)[a]		Mesiolingual transportation (mean ± SD)		Distal transportation (mean ± SD)	
Direction	MD	BL	MD	BL	MD	BL
H-files	0.13 ± 0.05 (n = 5)	0.12 ± 0.09	0.19 (n = 1)	0.009	0.07 ± 0.05 (n = 3)	0.08 ± 0.06
H-files + solvent	0.21 ± 0.11 (n = 6)	0.24 ± 0.24	0.03 ± 0.01 (n = 3)	0.05 ± 0.02	0.19 ± 0.07 (n = 5)	0.15 ± 0.03
HERO 642	0.12 ± 0.13 (n = 3)	0.08 ± 0.08	0.16 ± 0.19 (n = 3)	0.05 ± 0.05	0.15 ± 0.15 (n = 6)	0.08 ± 0.05
HERO 642 + solvent	0.18 ± 0.10 (n = 7)	0.31 ± 0.25	0.15 ± 0.03 (n = 4)	0.12 ± 0.07	0.14 ± 0.18 (n = 7)	0.08 ± 0.07

Number of the transported canals was presented. There were no statistical differences in same canal type between the groups. In addition, there was no statistical difference between mesiobuccal and mesiolingual canals in the same group.
[a]Perforated canals were not included.

Table 3 Direction and rate of canal transportation

	Apical transportation rate in direction		
	Mesiobuccal canals	Mesiolingual canals	Distal canals
H-files	90% M, 100% B	100% ML	70% D, 100% L
H-files + solvent	90% M, 100% B	100% ML	50% M, 50% D, 60% L, 40% B
HERO 642	100% M, 80% B	90% M, 100% L	50% D, 70% B
HERO 642 + solvent	70% M, 100% B	50% M, 100% L	60% D, 90% B

M, mesial; B, buccal; D, distal; L, lingual.

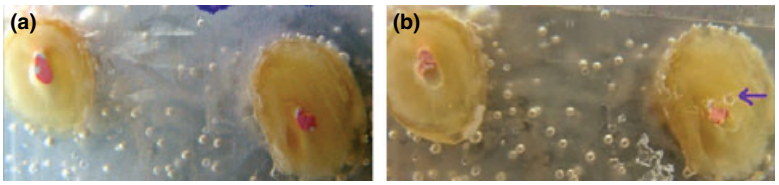

Figure 6 (a) Apical third in H-files group before retreatment. (b) Perforation occurred mesiobuccally (arrow). Canal fillings could be removed partially in both roots.

(Kosti *et al.* 2006) revealed no statistical superiority for rotary instruments. Similarly, in this study, which employed molar teeth, there was no difference between HERO 642 and hand files, in terms of their canal filling removal effectively in the apical thirds. However, hand instrumentation provided statistically cleaner canals in the middle third than the HERO 642, and left less root canal filling material overall. Bueno *et al.* (2006) used large single-rooted teeth and reported that 15% residual filling rate for hand files and solvent group. Their finding had almost the same results (16%) as the present study (Fig. 4). They found statistically less filling material when using hand files than rotary instruments. They also demonstrated approximately 30% and 35% residual filling material after using a K3 rotary system with and without solvent. It is noteworthy that a smaller residual filling rate (20–24%) occurred with HERO 642 files although molar teeth were used in the present study. In another study (Barletta *et al.* 2007), molar canals were used, and residual filling was observed using CT; the volume of residual filling was significantly smaller for mesiolingual canals than for mesiobuccal canals. In the present study, although no statistical differences occurred, mesiobuccal canals apically retained more filling material than mesiolingual canals (Table 1).

Centring ratio and perforations

The smaller the instrument size, the better the file remained centred in the canal regardless of the file type, because a catastrophic increase in transportation and centring ratio was observed when size 40 files were used versus size 25 (Kuhn *et al.* 1997). Whilst 0.02 taper, from size 20–30 files would be sufficient to enlarge a canal system in a primary root canal treatment, size 20–30 with greater taper and 35, 40 instruments with 0.02 taper were necessary for removal of the canal filling and re-instrumentation in this study. As these instruments are more rigid and stiffer, their use at the WL may result in complications like ledge and zip formation, transportation and perforation (Thompson & Dummer 2000a,b). Although HERO 642 instruments have modified noncutting tips (Schäfer & Fritzenschaft 1999) and potential perforation risk is lower than hand instrumentation in severely curved root canals (Schäfer 2001), many lateral perforation occurred in the apical sections at 48% rate. Stiffness of the size 35 and 40 HERO 642 master apical files resulted in ledges, subsequent lateral transportations and perforations. In a clinical study, ledge formation was investigated and the highest ledge formation rate (57%) was reported after retreatment of mandibular molar teeth. In addition, the most affected canals were determined as the mesiobuccal canals of these molar teeth, 52%. It is known that curvature of a root canal is the major pre-disposing factor; however, this complication rate was nearly same in moderately and severely curved root canal systems (Kapalas & Lambrianidis 2000). In the present study, moderately curved mesial canals were re-instrumented, and the filling of the apical third could not be removed in mesiobuccal canals with lateral perforation. Eventually, the percentage of the residual filling in apical thirds was significantly larger than in middle and coronal thirds in these cases.

In the present study, HERO 642 system was evaluated as a single tool in retreatment of mandibular

molar teeth. Actually, a combination of methods is generally required, and postoperative complications like lateral perforation and instrument fracture can be decreased by using of solvent (Ruddle 2002, Taşdemir *et al.* 2008).

Conclusion

The HERO 642 system was not more successful than hand files for filling removal in the root canals of mandibular molar teeth. The apical canal centring ability was similar in both methods.

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