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Opinions and attitudes of endodontists and general dental practitioners in the UK towards the intra-canal fracture of endodontic instruments. Part 2

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Abstract

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Aim To investigate the attitudes of general dental practitioners (GDPs) and endodontists in the UK towards management of fractured endodontic instruments.

Methodology A questionnaire was sent to 330 systemically selected GDPs and all endodontists working in the UK (170). It was accompanied by a covering letter explaining the aims of the study and indicating that all the information given would remain confidential. Those who did not respond to the first mailing were sent another two mailings. Data were analysed using chi-square test at $P \leq 0.05$.

Results The overall response rate was 75%. Only 18.5% of respondents reported that they would retrieve instruments located in the apical third of root canals with a significantly higher proportion of endodontists (25.9%) compared with that of GDPs (14%) doing so. A significantly higher proportion of endodontists (98.5%) used ultrasonics for removal of fractured instruments compared with GDPs (75.8%). The most common complication of fractured instrument retrieval was thought to be excessive removal of dentine (67%). The majority of respondents (88.5%) reported that they would leave the unsuccessfully removed file *in situ* and obturate the root canal.

Conclusion Both endodontists and GDPs were aware of the limitations of root canal anatomy when removal of fractured instruments was considered. Excessive removal of dentine, the most common complication associated with the removal process, suggests the need for more conservative techniques. Both endodontists and GDPs demonstrated a conservative approach when management of fractured instruments failed. Further studies regarding attitudes of GDPs and endodontists towards some specific aspects of fractured instruments management are required.

Keywords: endodontic files separation, instruments fracture, questionnaire, removal, retrieval, survey.

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Introduction

Fracture of endodontic instruments is not an uncommon incident during root canal treatment. Previous studies have reported prevalences ranging from 1% to 6% (Crump & Natkin 1970, Sjögren *et al.* 1990, Hülsmann & Schinkel 1999, Parashos *et al.* 2004, Spili *et al.* 2005, Di Fiore *et al.* 2006, Iqbal *et al.* 2006, Knowles *et al.* 2006, Wolcott *et al.* 2006). Questionnaire studies have shown different experiences of fractured instruments amongst dental practitioners. Barbakow & Lutz (1997) reported that 76% of respondents had experienced fracture of LightSpeed rotary instruments in Switzerland. Another survey conducted in Australia showed that 74% of rotary instrument users experienced fracture of rotary instruments (Parashos & Messer 2004). In a recent survey

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conducted in the UK, 89% of general dental practitioners (GDPs) and endodontists have experienced fracture of endodontic instruments (Madarati *et al.* 2008).

Although removal of fractured instruments is difficult, time consuming, and may lead to complications, it is accepted that such an approach should be considered. Only when conventional root canal retreatment has failed, leaving of the fractured fragment be considered. Many studies have investigated different techniques for removal of fractured instruments and different success rates have been reported (Hülsmann & Schinkel 1999, Ward *et al.* 2003a,b, Shen *et al.* 2004, Souter & Messer 2005, Suter *et al.* 2005). Also, complications associated with fractured instrument removal have been studied (Ward *et al.* 2003a,b, Souter & Messer 2005). Other studies have addressed the outcome of treatment of cases involving retained fractured segments (Spili *et al.* 2005). However, little information is available regarding the attitudes and experience of dental practitioners in the management of fractured instruments.

What do dentists do when endodontic instruments fracture, which technique(s) do they use for removal of fractured instruments and what approach(s) do they take when management of fractured instruments does' not succeed? This paper will cover the second part of a questionnaire carried out to investigate the attitudes and opinions of GDPs and endodontists in the United Kingdom towards aspects of endodontic instrument fracture. In particular, this paper will focus on aspects of intra-canal-fractured instrument management. It was hypothesized that there would be no significant difference between endodontists and GDPs regarding techniques used for removal of fractured instruments.

Materials and methods

A survey of GDPs and endodontic specialists in the UK was carried out between January and March 2007 regarding their experience in the management of fractured instruments. The methodology was that described by (Madarati *et al.* 2008). Briefly, following a pilot study and a sample size calculation, a questionnaire was sent to 330 systematically selected GDPs and all endodontic specialists working in the UK (170). The questionnaire comprised both close-ended and partially close-ended questions. It was accompanied by a covering letter explaining the aims and objectives of the study and indicating that all information given would remain confidential and anonymous. Those who did not respond to the first mailing were sent another two reminders. Data were analysed using chi-square test at $P \leq 0.05$.

Results

Response rate details

The overall response rate was 75% with 70.92% for GDPs and 82.82% for endodontists (Madarati *et al.* 2008).

Management of instruments fractured at different locations within root canal

Coronal third

The majority of respondents (89.6%) reported that they would try to retrieve fractured instruments located in the coronal one-third (Table 1). A significantly higher proportion of endodontists (94%) adopted this approach compared with that of GDPs (86.9%) ($\chi^2 = 4.57$, d.f. = 1, $P = 0.033$). Only two respondents (0.6%) reported that they would leave the fractured segment *in situ*, obturate and review.

Middle third

Overall, 58% of respondents said that they would try to remove a fractured instrument located in the middle third of the canal (Table 2). A significantly higher proportion of endodontists (74.6%) adopted this approach compared with GDPs (48%) ($\chi^2 = 24.35$, d.f. = 1, $P < 0.001$). One hundred and five (29.6%) of respondents reported that they would attempt to bypass fractured instruments with no significant difference

Table 1 Management of instruments fractured in the coronal part of the root canal

Respondents	Retrieve	Bypass	Leave and review	Refer to a specialist	Total
GDPs	192 (86.9)	23 (10.4)	1 (0.5)	5 (2.3)	221 (100)
Endodontists	126 (94)	7 (5.2)	1 (0.7)	0 (0)	134 (100)
Total	318 (89.6)[a]	30 (8.5)[a]	2 (0.6)	5 (1.4)[a]	355 (100)

The values presented in parentheses are percentages.
[a]A significant difference between endodontists and general dental practitioners (GDPs) was found.

Table 2 Management of instruments fractured in the middle part of the root canal

Respondents	Retrieve	Bypass	Leave and review	Refer to a specialist	Total
GDPs	106 (48)	71 (32.1)	11 (5)	(14.9)	221 (100)
Endodontists	100 (74.6)	34 (25.4)	0 (0)	0 (0)	134 (100)
Total	206 (58)[a]	105 (29.6)	11 (3.1)[a]	33 (9.3)[a]	355 (100)

The values presented in parentheses are percentages.
[a]A significant difference between endodontists and general dental practitioners (GDPs) was found.

between endodontists and GDPs (25.4% and 32.1% respectively) ($\chi^2 = 1.86$, d.f. = 1, $P = 0.172$). Only 14.9% of GDPs reported that they would refer the patient to a specialist.

Apical third

Overall, there was a significant difference between endodontists and GDPs in management of instruments fractured in the apical third (Table 3). Only 18.5% of respondents reported that they would attempt to retrieve fractured instruments. A significantly higher proportion of endodontists (25.9%) compared with GDPs (14%) ($\chi^2 = 7.098$, d.f. = 1, $P = 0.008$), with approximately 21% of GDPs reporting that they would refer the patient to a specialist.

Success of fractured instrument removal

Success was categorized as follows: (i) 1–25% (poor success); (ii) 26–50% (fair success); 51–75% (good success); and (iv) 76–100% (very good success). Results of this question were divided into three parts according to the location at which the file fractured.

Coronal portion

Most respondents (59.1%) reported a very good success rate (76–100%) with a significant difference between endodontists and GDPs ($\chi^2 = 88.77$, d.f. = 3, $P < 0.001$; Table 4). Whilst the vast majority of endodontists (89.9%) reported a very good success rate, only 38.7% of GDPs did so. Overall, the majority of respondents (78.3%) reported a success rate of over 50% with a significantly higher proportion of endodontists (99.2%) compared with that of GDPs (64.4%) ($\chi^2 = 55.25$, d.f. = 1, $P < 0.001$) doing so.

Table 3 Management of instruments fractured in the apical part of the root canal

Management type	GDPs	Endodontists	Total
Retrieve	31 (14)	35 (25.9)	66 (18.5)
Bypass	47 (21.3)	66 (48.9)	113 (31.7)
Leave and review	94 (42.5)	34 (25.2)	128 (36)
Surgical approach	1 (0.5)	0 (0)	1 (0.3)
Extraction	1 (0.5)	0 (0)	1 (0.3)
Refer to a specialist	47 (21.3)	0 (0)	47 (13.2)
Total	221 (100)	135 (100)	356 (100)

The values presented in parentheses are percentages.
Overall, there was a significant difference between endodontists and general dental practitioners (GDPs).

Middle portion

Only 19.3% of respondents reported a very good success rate in removal of fractured instruments located in the middle portion of the root canal (Table 5). There was a significant difference between endodontists and GDPs ($\chi^2 = 92.32$, d.f. = 3, $P < 0.001$). The highest proportion of endodontists (36.4%) reported a very good success rate compared with 7.5% reported by GDPs. Overall 40.8% of respondents reported a success rate of over 50% with a significantly higher proportion of endodontists (70.5%) compared with that reported by GDPs (20.3%) ($\chi^2 = 79.70$, d.f. = 1, $P < 0.001$).

Apical portion

The majority of respondents (79.1%) reported a poor success rate with a significantly higher proportion of GDPs (89.2%) compared with that reported by endodontists (64.8%) ($\chi^2 = 26.79$, d.f. = 3, $P < 0.001$). On the other hand, only 1.7% of respondents reported a very good success rate with a significantly higher proportion of endodontists (3.2%) compared with that reported by GDPs (0.6%) (Table 6). Only 6.6% of respondents reported a success rate of over 50% with a significantly higher proportion of endodontists (12%) compared with that of GDPs (2.8%) ($\chi^2 = 9.88$, d.f. = 1, $P = 0.002$) doing so.

Technique(s) used for removal of fractured instruments

The most frequently used technique for removal of fractured instruments was ultrasonics (84.6%) followed

Table 4 Success rate of removal of fractured instruments from the coronal third of the root canal

Respondents	1–25% success rate	26–50% success rate	51–75% success rate	76–100% success rate	Total
GDPs	24 (12.4)	45 (23.2)	50 (25.8)	75 (38.7)	194 (100)
Endodontists	1 (0.8)	0 (0)	12 (9.3)	116 (89.9)	129 (100)
Total	25 (7.7)	45 (13.9)	62 (19.2)	191 (59.1)	323 (100)

The values presented in parentheses are percentages.
Overall, there was a significant difference between endodontists and general dental practitioners (GDPs).

Table 5 Success rate of removal of fractured instruments from the middle third of the root canal

Respondents	1–25% success rate	26–50% success rate	51–75% success rate	76–100% success rate	Total
GDPs	77 (41.2)	72 (38.5)	24 (12.8)	14 (7.5)	187 (100)
Endodontists	6 (4.7)	32 (24.8)	44 (34.1)	47 (36.4)	129 (100)
Total	83 (26.3)	104 (32.9)	68 (21.5)	61 (19.3)	316 (100)

The values presented in parentheses are percentages.
Overall, there was a significant difference between endodontists and general dental practitioners (GDPs).

Table 6 Success rate of removal of fractured instruments from the apical third of the root canal

Respondents	1–25% success rate	26–50% success rate	51–75% success rate	76–100% success rate	Total
GDPs	157 (89.2)	14 (8))	4 (2.3)	1 (0.6)	176 (100)
Endodontists	81 (64.8))	29 (23.2)	11 (8.8)	4 (3.2)	125 (100)
Total	238 (79.1)	43 (14.3)	15 (5)	5 (1.7)	301 (100)

The values presented in parentheses are percentages.
Overall, there was a significant difference between endodontists and general dental practitioners (GDPs).

by the use of Masserann trephination (35.4%) (Table 7). The majority of endodontists reported use of ultrasonics (98.5%) and this was significantly higher than GDPs (75.8%) ($\chi^2 = 32.76$, d.f. = 1, $P < 0.001$). However, there was no significant difference between GDPs and endodontists (38.6% and 30.4% respectively) regarding the use of the Masserann technique ($\chi^2 = 2.46$, d.f. = 1, $P = 0.117$).

Table 7 Techniques used for removal of fractured instruments

Techniques	GDPs	Endodontists	Total
Ultrasonic	163 (75.8)	133 (98.5)	296 (84.6)[a]
Masserann	83 (38.6)	41 (30.4)	12 (35.4)
Files Braiding	19 (8.8)	13 (9.6)	32 (9.1)
Cancellier	4 (1.9)	10 (7.4)	14 (4)[a]
IRS	5 (2.3)	6 (4.4)	11 (3.1)
Forceps	1 (0.5)	1 (0.7)	2 (0.6)
PRS	0 (0)	1 (0.7)	1 (0.3)
Multi-techniques	57.1%	67.3%	63.4%

The values presented in parentheses are percentages.
[a]A significant difference between endodontists and general dental practitioners (GDPs) was found.

The use of magnification

Overall, 70.4% of respondents reported using magnification whilst removing fractured instruments (Table 8). The vast majority of endodontists (98.5%) reported the use of magnification and this was significantly higher than that reported by GDPs (52.8%) ($\chi^2 = 83.36$, d.f. = 1, $P < 0.001$). In the case of an affirmative answer, respondents were asked to specify what type(s) of magnification they used. Of those 51% who used magnification used a microscope with a significantly

Table 8 Respondents details regarding magnification use whilst removal of fractured instruments

	Use of magnification	Loupes	Microscope	Total
GDPs	114 (52.8)	105 (92.1)	12 (10.5)	114 (100)
Endodontists	133 (98.5)	44 (33.1)	114 (85.7)	133 (100)
Total	247 (70.4)	149 (60.3)	126 (51)	247 (100)

The values presented in parentheses are percentages.
Overall, there was a significant difference between endodontists and general dental practitioners (GDPs).

higher proportion of endodontists (85.7%) compared with that of GDPs (10.5%) ($\chi^2 = 138.86$, d.f. = 1, $P < 0.001$) doing so.

Complications associated with removal of fractured instruments

Overall, 61.8% of respondents reported that they experienced complications whilst removing fractured instruments with a significantly higher proportion of endodontists (71.6%) compared with that of GDPs (55.6%) doing so ($\chi^2 = 8.97$, $P = 0.03$) (Table 9). Respondents were asked to specify what type of complications they experienced when attempted to remove fractured instruments (proportions calculated according to those who had complications).

Weakened tooth
Overall, 67.4% of respondents reported excessive loss of tooth structure. No significant difference was found between endodontists (72.9%) and GDPs (63%) ($\chi^2 = 2.37$, d.f. = 1, $P = 0.124$).

Root canal perforation
Overall, 46.5% of respondents reported experience of root canal perforation. There was no significant difference between endodontists (47.9%) and GDPs (45.4%) ($\chi^2 = 0.14$, d.f. = 1, $P = 0.711$).

Fracture of another instrument
Overall, 40.5% of respondents experienced fracture of another instrument. There was no significant difference between endodontists and GDPs (38.5% and 42% respectively) ($\chi^2 = 0.27$, d.f. = 1, $P = 0.606$).

Extrusion of the fractured segment
Overall, 18.6% of respondents experienced extrusion of the fractured segment through the apex. A significantly higher proportion of endodontists (25%) experienced this complication compared with that of GDPs (13.4%) ($\chi^2 = 4.68$, d.f. = 1, $P = 0.03$).

Other complications
Overall, 8.4% of respondents reported other complications not listed in the questionnaire such as ledge formation or blockage of the canal, and fracture of the ultrasonic tip.

Management of un-removed or un-bypassed fractured instruments

Respondents were asked to indicate their approach when they experience failure in management of fractured instruments (Table 10). The majority of respondents (88.5%) reported that they would leave the instrument *in situ* and obturate the canal. The vast majority of endodontists (96.9%) considered this approach and this was significantly greater than that reported by GDPs (82.9%) ($\chi^2 = 15.26$, d.f. = 1, $P < 0.001$). Only 10.6% performed surgery with a significantly greater proportion of endodontists (16%) compared with that of GDPs (7%) ($\chi^2 = 6.72$, d.f. = 1, $P = 0.009$) doing so.

Discussion

Surveys are a research tool that provides information about opinions, attitudes and behaviour of respondents (Lydeard 1991). This survey was conducted to indicate how GDPs and endodontists manage fractured instruments.

The first question was related to the management of fractured instruments in different parts of the root canal (coronal, middle and apical third). The results revealed that the deeper the fractured instrument, the less likely clinicians would be attempt to remove it. Whilst the majority (86.9%) of respondents would attempt to retrieve the fractured segment from the coronal part, only 18.5% would do from the apical part. In this study there were no questions related to the type of tooth, root canal, root canal curvature, type and length of fractured instrument and other confounding factors which might influence the operator's

Table 9 Complications of removal of fractured instruments

	Fracture another instrument	Root perforation	Weakened tooth	Instrument extrusion	Others	Total
GDPs	50 (42)	54 (45.4)	75 (63)	16 (13.4)	14 (11.8)	119 (55.6)
Endodontists	37 (38.5)	46 (47.9)	70 (72.9)	24 (25)	4 (4.2)	96 (71.6)
Total	87 (40.5)	100 (46.5)	145 (67.4)	40 (18.6)[a]	18 (8.4)[a]	215 (61.8)[a]

The values presented in parentheses are percentages.
[a]A significant difference between endodontists and general dental practitioners (GDPs) was found.

Table 10 Management of un-removed or un-bypassed instruments

	Left the segment	Performed surgery	Extracted the tooth	Referred to a specialist
GDPs	165 (82.9)	14 (7)	18 (9)	91 (45.5)
Endodontists	127 (96.9)	21 (16)	6 (4.6)	3 (2.3)
Total	292 (88.5)[a]	35 (10.6)[a]	24 (7.3)	94 (28.4)[a]

The values presented in parentheses are percentages.
[a]A significant difference between endodontists and general dental practitioners (GDPs) was found.

decision. However, figures reflect the fact that location of fractured instruments within the root canal is one of the main factors that affect the decision regarding management. This is especially applicable for GDPs as a higher proportion referred, or would refer, fractured instruments if located in the apical or middle part (21.35% and 14.9% respectively) compared with only 2.3% in the coronal part. Similarly, a higher proportion of endodontists (48.9%) tried, or would try, to bypass the fractured segment located in the apical part of the root canal compared with 25.9% who tried, or would try, to retrieve it. Visualization and the ability to reach the fractured instrument deeply located within the root canal without damaging the root (weakening and perforating) is the main challenge. This is especially in the case of curved canals, in which instruments are more likely to engage the canal walls and demand more time and efforts without guarantee of success. However, the practitioner's experience may be a significant factor in the decision on management of instruments fractured at different locations. Nevertheless, it can be said that both GDPs and endodontists are aware of the significance of root canal anatomy when removal of fractured instruments is considered. This was confirmed by the findings related to experience in success and failure in removal of fractured instruments. Whilst the majority of respondents (78.3%) reported retrieval success rate of over 50% when a fractured instrument was located in the coronal one-third of the root canal, 40.8% did so when it was in the middle third. The lowest figure of over 50% success was reported for the apical third (6.6%). These results were consistent with those reported in previous studies. Hülsmann & Schinkel (1999) found the lowest success rate of 59% when fractured instruments were removed from the apical third compared with middle and coronal thirds (69% and 100%). A recent study showed only a 24% success rate and seven cases of root perforation when fractured instruments were removed from the apical third (Souter & Messer 2005). Unlike the coronal and middle third, fractured instruments located in the apical third are usually inaccessible and are more likely to engage with the canals walls. It can be predicted that most failed cases in the apical third were located at or beyond the root canal curvature. All studies reported a lower success when fractured instruments were located at or beyond the curvature rather than before the curvature (Hülsmann & Schinkel 1999, Ward *et al.* 2003a,b, Shen *et al.* 2004, Souter & Messer 2005, Suter *et al.* 2005). In this study, the highest figures of failures were reported when a fractured instrument was located in the most anatomically inaccessible regions; in molars and in the apical one-third of the root canal (88.4% and 84.8% respectively).

The majority of respondents (84.6%) used ultrasonics for removal of fractured instruments, and nearly all endodontists (98.5%) doing so. Dental education may be influential on practitioners' choice for such a technique for removal of fractured instruments. Ultrasonic techniques are relatively easy can effectively dislodge the fractured segment and have been reported as being successful (Nagai *et al.* 1986, Ward *et al.* 2003a, Wei *et al.* 2004). It can be used in narrow and curved canals especially when the fractured segment is located apically (Shen *et al.* 2004). Recently, titanium-based nickel titanium ultrasonic tips have been introduced and are claimed to be suitable for use in curved canals. However, the combination of ultrasonics with other methods is still recommended for optimal results (Hülsmann 1993, Ruddle 2004, Shen *et al.* 2004, Suter *et al.* 2005, Terauchi *et al.* 2007). In this study, 63.4% of respondents reported the use of more than one technique for retrieval of fractured instruments. These respondents may use several techniques in individual cases.

Masserann trephine techniques have been used for 40 years and different success rates have been reported (25–55%) (Masserann 1966, Feldman *et al.* 1974, Fors & Berg 1983, Hülsmann 1990, Okiji 2003). However, a low proportion of participants (35.4%) used this technique with a significantly higher proportion of GDPs (38.6%) compared with that of endodontists (30.4%) doing so. This may be explained by the fact that such a technique may require excessive removal of sound dentine to enable placement of the extractor within the root canal and this may lead to root perforation (Yoldas *et al.* 2004).

There was a significant difference between endodontists and GDPs with respect to the use of magnification as well as the type of magnification used. Whilst the majority of endodontists (85.7%) reported that they

used an operating microscope, only 10.5% of GDPs did so. Financial considerations may be a factor limiting its use in general dental practice. Most recent studies, if not all, have recommended the microscope as being an essential prerequisite for successful management of fractured instruments (Ward 2003, Ward *et al.* 2003a,b, Wei *et al.* 2004, Suter *et al.* 2005). It is generally accepted that the better the visibility, the fewer the complications. This study suggests the need to introduce the use of dental microscope in general dental practice for optimal management of fractured instruments.

Overall, 61.8% of respondents reported that they experienced complications during or after removal of fractured instruments. Previous studies have reported different types of complications. Even with the most sophisticated techniques and where segments are removed, complications may still occur (Ward *et al.* 2003a,b, Souter & Messer 2005, Suter *et al.* 2005). This is especially so when narrow and curved canals are involved. In the present study, a significantly higher proportion of endodontists tried, or would try, to remove fractured instruments, especially those located in the apical third, compared with GDPs. This may explain the higher proportion of endodontists (71.6%) reporting complications. Moreover, this study showed that the proportion of endodontists taking ≥45 min when managing fractured instruments (59.5%) was significantly higher than that of GDPs (37.8%). It has been reported that the longer the time of treatment, the greater the potential for complications and the lower the success rate (Ward 2003, Suter *et al.* 2005).

The most frequently reported complication (67.4%) was excessive removal of sound dentine. In most cases, if not all, sufficient enlargement of the root canal coronal to the fractured segment is essential to visualize the most coronal aspect. Also, a straight line access and staging platform must be prepared before ultrasonic removal of fractured instruments is attempted (Ruddle 2004). The further the fractured instrument is beyond the curvature or deeper within the canal, the less dentine thickness remaining after fragment removal and the greater the potential for root weakening (Ward *et al.* 2003a). Consequently, root perforation is highly likely. In this study 46.5% of respondents reported root canal perforation, which was the second most common complication. It is very important that clinicians take into consideration both the possibility of removing fractured instruments and the potential complications. Other complications such as ledging, fracture of other instruments, canal blocking were reported. However, these findings suggest the need for more conservative techniques for removal of fractured instruments. A technique that might be considered for investigation in the future is laser irradiation. One study has indicated the advantages of using lasers in deeper portions of the root canal with a low risk of root fracture within a relatively short time (Yu *et al.* 2000). Nevertheless, using of this technique in curved canals and the thermal effects on periodontal tissues are still concerns and require future investigation (Yu *et al.* 2000).

Respondents were asked what they did when they failed to remove or bypass fractured instruments. The majority (88.5%) reported that they would leave the fractured segment(s) *in situ* and continued treatment with follow-up. In a previous study, 97% of dentists reported a similar approach (Parashos & Messer 2004). However, unlike the present study, failure was categorized as failure to remove of fractured instruments. In the present study a significantly higher proportion of endodontists (96.9%) reported they would leave the segment *in situ* compared with that of GDPs (82.9%). A total of 2.3% of endodontists reported that they would refer unsuccessful cases to another specialist with 45.5% of GDPs reported the same approach. Endodontists are the last resort in the treatment chain and the final approach lies in their hands. The only alternative is to fill the canal to the level of the fractured instrument and prevent the risk of a further infection. This study clearly demonstrated the conservative attitude of respondents which might be explained by their perception and experience that the prognosis is favourable despite the presence of a fractured instrument (Spili *et al.* 2005). A low proportion of respondents performed surgery or extracted the involved tooth (10.6% and 7.3% respectively). Further studies regarding factors affecting dentist's decisions in approaching of failed cases are required.

Conclusion

The majority of GDPs and endodontists incorporated ultrasonics in their armamentarium for removal of fractured endodontic instruments. It also showed that they are aware of the limitations influenced by root canal anatomy when removal of fractured instruments is considered. Excessive removal of sound dentine, which was the most common complication associated with fractured instrument management, suggests the need for more conservative techniques. Both endodontists and GDPs reported a conservative approach

towards unsuccessful management of fractured instruments. Although the use of the dental operating microscope was common in endodontic specialist practice, this study suggests the need to introduce the advantages of its use in general dental practice.

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