Questionnaire survey on the use of rotary nickel–titanium endodontic instruments by Australian dentists

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Abstract

Parashos P, Messer HH. Questionnaire survey on the use of rotary nickel–titanium endodontic instruments by Australian dentists. *International Endodontic Journal,* **37**, 249–259, 2004.

Aim To ascertain the extent of the adoption and use of rotary nickel–titanium (NiTi) instruments and techniques in general dental practice and specialist endodontic practice in Australia in 2001.

Methodology A questionnaire survey comprising 43 questions was developed by first creating questions, then pilot testing with 10 postgraduate students in endodontics, followed by a final revision. The final series of questions covered demographics, patterns of rotary NiTi usage, issues associated with NiTi usage and training in NiTi use. The sampling frame was 908, comprising 64 endodontists and 844 general dentists.

Results The overall response rate was 87%. Rotary NiTi instruments were used by 22% of general dentists and 64% of endodontists. The two main reasons for not using rotary NiTi were 'no perceived advantage' and 'too fragile'. Instrument fracture had been experienced by 74% of respondents, and 72% of these had fractured one to five files for the two main perceived reasons of 'excessive pressure on the file' and 'over-usage'. The next two most common problems encountered were 'binding' (53%) and 'ledging' (45%). Very high proportions of positive experiences were noted. Most respondents (73%) had attended one or more continuing education courses, most of which were provided by dental supply companies (64%).

Conclusions The results indicate a sensible and responsible approach to the incorporation of rotary NiTi instruments and techniques into root canal treatment. Dentists were aware of the limitations of the new technology, but were taking steps to become familiar with the properties and behaviour of the instruments. Instrument fracture was common, but it was of low frequency and did not deter dentists from using the technology.

Keywords: questionnaire survey, rotary NiTi.

Received 4 June 2003; accepted 2 December 2003

Introduction

The cleaning and shaping of root canal systems by various techniques of debridement has been, and still is, a complex procedure that can be daunting for both the patient and the clinician. Nevertheless, endodontics is of major interest in general dental practice. In Australia, for example, this is evident by the fact that more than 10% of dentist members of the Australian Dental Association Incorporated (ADA Inc.) are also members of the Australian Society of Endodontology Incorporated (Moloney 2002).

Traditionally, the hand instruments used in root canal shaping have been made of stainless steel, but these instruments lack flexibility, particularly in the larger sizes, and can sometimes lead to procedural errors (Serene *et al.* 1995) resulting in a decreased success rate for endodontic treatment (Sigurdsson 2002). These errors may be partly because of the nature and limitations of stainless steel instruments. Furthermore, little improvement has occurred over the years in the designs of these stainless steel instruments. Briseño & Sonnabend (1991) commented that no hand stainless steel instrument produced ideal results although their

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in vitro results led them to conclude that the nine instruments compared produced clinically acceptable canal shapes.

Soon after the introduction of nickel–titanium (NiTi) instruments (Walia *et al*. 1988), NiTi rotary instrumentation began to increase in popularity. The super-elastic property of NiTi, coupled with advanced instrument design, promised to allow safe and effective instrumentation of curved and narrow root canals using handpiece-driven instruments operated at low speeds (Serene *et al*. 1995).

However, very little is known about the adoption of this particular new technology into clinical dental practice, with specific reference to familiarity and philosophies. Only Barbakow & Lutz (1997) have attempted to study dentists' attitudes towards, and experiences with, rotary NiTi instruments and techniques. Using a questionnaire survey of general dentists in Switzerland, they found that of 305 participants who attended a continuing education course in the use of a specific rotary NiTi technique, only 58% responded, but of those, 80% had integrated the new technology into their practice. Generally, little information is available regarding the attitude of general dental practitioners towards new endodontic concepts, techniques and instruments, and on how far these have been incorporated into daily practice (Slaus & Bottenberg 2002).

Consequently, the current questionnaire survey was conducted to add to our knowledge concerning the use of rotary NiTi instruments and techniques in general dental practice and in specialist endodontic practice. In particular, the following aspects were investigated: demographics, patterns of NiTi usage, issues (problems and experiences) with NiTi usage, and education and training in NiTi use.

Methods

Survey instrument and questionnaire implementation

The survey was a mailed self-administered questionnaire because the sample size was large and geographically widespread. This, together with the noncomplex nature of the information sought did not warrant an interview-type survey. Some of the questions asked by Barbakow & Lutz (1997) were used as a starting point and expanded upon to create an initial series of questions covering issues related to the use of rotary NiTi instruments and techniques. A pilot questionnaire was tested on 10 volunteer postgraduate students in endodontics at the University of Melbourne, Australia. From their responses and comments, the questionnaire was modified to arrive at the final version. The questionnaire survey (available from the authors) comprised a total of 43 questions, many of which had multiple parts, over six single-sided A4 pages. The questions included both closed- and open-format questions. The closed-format questions offered from 2 to 12 categorical choices but with an average of 4. The questionnaire was structured as follows:

- Part A. Demographics – 3 questions (1 closed; 2 open).
- Part B. Patterns of rotary NiTi usage – 18 questions (17 closed; 1 open).
- Part C. Issues associated with NiTi usage – 11 questions (11 closed).
- Part D. Training in NiTi use – 11 questions (7 closed; 4 open).

The sampling frame population was 908 and comprised 64 endodontists and 844 general dentists. This sample size was based on a formula for calculating sample size (Dillman 2000), which takes the following factors into consideration:

1 The number of people in the questionnaire survey population;
2 The proportion of the population expected to choose one of two response categories;
3 An acceptable amount of sampling error; and
4 The statistical confidence level.

The sample consisted of all practising Australian endodontists who were members of the Australian and New Zealand Academy of Endodontists (ANZAE), and a stratified systematic sample of Australian dentists who were members of the ADA Inc. Stratification was according to state of Australia and whether metropolitan or rural, which was based on postcode zones as determined by Australia Post according to distance from the capital city within each state. The total number in the target population was 5742, and the sampling frame represented approximately 16% of all practising Australian dentists. In order to ensure equal representation from each stratum, the stratum sample size proportions were exactly the same as the proportion of all dentists in each stratum relative to the overall number of dentists in Australia. That is, if a stratum contained x% of all Australian dentists then the sample size from that stratum was x% of the total sample size.

The questionnaire was accompanied by a letter explaining the objectives of the survey and requesting participation. The letter explained that the survey was confidential and de-identified. A numbered reply paid envelope was included but there were no identifying

marks on the questionnaire itself. The letter stated that when the questionnaire was returned, a third person unrelated to the study would remove the questionnaire from the envelope and separate them. That person had no access to the coded mailing list and only recorded the number codes from the envelopes as they were received. The letter further made clear that the code numbers would be cross-checked against the list of participants to enable follow-up, and that the results would be reported in such a way as to keep the identity of the participants anonymous. Nonrespondents received another two mail-outs comprising a reminder letter and another copy of the questionnaire. As a final contact, the remaining nonrespondents received a telephone call from another person unrelated to the study. Ethics approval was granted by the Health Sciences Human Ethics Subcommittee of the University of Melbourne.

The data collection period extended from June 2001 to November 2001. The raw data were collected and manually entered into a Microsoft® Excel spreadsheet (Microsoft Corporation, WA, USA). Each possible response to each question was allocated its own column and any non-numerical data were numerically coded for ease of data manipulation. The spreadsheet was imported into Minitab™ (Minitab Inc., State College, PA, USA) and SPSS™ (SPSS Inc., Chicago, IL, USA) Statistical software analysis was carried out using the Chi-squared test, Fisher's exact test and the Linear-by-Linear Association test. Fisher's exact test was used when the Chi-squared value was low and the test produced at least one expected cell count less than five and may have been unreliable; the higher *P*-value is reported. These analyses tested for differences both between and within the endodontist and general dentist groups. The differences with increasing experience with the technology were also tested. The significance level was set at $P < 0.05$. Because of the small number of endodontists relative to the number of general dentists, most data from both groups are combined unless there were interesting or significant differences between the two, or within either group.

Results

The response rate details are based on the numerator consisting of completed or partially completed questionnaires and the denominator consisting of all eligible sample units (Locker 2000). The following ratios were achieved:

- Overall response rate = 731/840 = 87%,
- General dentist response rate = 673/776 = 87%, and
- Endodontist response rate = 58/64 = 91%.

Table 1 Use of rotary NiTi according to type of practice

Practice type	Number	Use	Do not use
General dentist	673	151 (22)	522 (78)
Endodontist	58	37 (64)[a]	21 (36)
Total	731	188 (26)	543 (74)

Percentage values in parentheses.
[a]Significantly more than general dentists ($\chi^2 = 47.81$, 1 df; $P < 0.001$).

The completion rate of the survey was 80.5% (731 of 908 questionnaires mailed). Of the original sample size of 908, 68 proved to be ineligible because of having changed address, having retired or specializing in another discipline. Of the remaining 840, 776 were general dentists of whom 103 chose not to participate in the survey. Most of these (78) did not give reasons for not participating. Of the remainder, 16 said that they would return their questionnaire but did not, five stated that they did not want to complete the questionnaire because they were not interested in doing so, and four stated that they did not have a questionnaire and agreed to be sent another, but still did not return it. Of the six endodontists who did not participate, none gave a reason.

Overall, of the 731 usable responses, 26% of dentists used rotary NiTi at the time of the survey, with 22% of general dentists and 64% of endodontists using the new technology (Table 1). Endodontists were significantly more likely to use rotary NiTi than general dentists ($\chi^2 = 47.806$, 1 df; $P < 0.001$).

Part A. Demographics

Year of graduation

The overall range of graduation years spanned 1946–2000 (Table 2). For statistical analysis, the 1946–1950 and 1951–1960 groups were combined. The overall Chi-squared test was not significant. In comparison to

Table 2 Response details for year of graduation[a]

Range	Number	Use NiTi	Do not use NiTi
1946–1950	4	1 (25)	3 (75)
1951–1960	19	4 (21)	15 (79)
1961–1970	95	25 (26)	70 (74)
1971–1980	240	62 (26)	178 (74)
1981–1990	234	72 (31)[b]	162 (69)
1991–2000	139	24 (17)	115 (83)
Total	731	188 (26)	543 (74)

[a]Percentage values in parentheses refer to each range of years.
[b]Significantly more than graduates in the range 1991–2000 ($\chi^2 = 8.319$, 1 df; $P = 0.004$).

1991–2000 graduates, 1981–1990 graduates had a significantly higher usage of rotary NiTi ($\chi^2 = 8.319$, 1 df; $P = 0.004$); all the other categories (1946–1960, 1961–1970 and 1971–1980) did not differ significantly from the 1991–2000 group. Furthermore, comparison between various combinations of the ranges of graduation year indicated no significant differences.

Main practice location and origin of dental degree

Of the 727 dentists who provided their main practice postcode, 565 (78%) practised in a metropolitan location and the remainder practised in a rural location. Of the 711 dentists who provided the origin of their dental degree, 622 (87%) were graduates of Australian universities and the remainder were trained overseas. No statistically significant differences were noted between the proportions of those who used or did not use rotary NiTi when considering practice location (metropolitan or rural) and origin of degree (Australia or overseas).

Part B. Patterns of rotary NiTi usage

The first question of this part of the survey asked whether or not the respondent currently used rotary NiTi. If they answered 'No', these respondents were then asked only whether or not they had tried rotary NiTi and were asked for reasons. Those who did use the instruments were asked to complete the remainder of the questionnaire.

Negative ('No') response to the use of rotary NiTi

Of the 543 dentists who did not use rotary NiTi instruments at the time of the survey, 75 did not indicate whether or not they had tried the technology (Table 3). Of the 468 dentists who did answer the question, 81% had never tried rotary NiTi, while 19% had tried the instruments but were not currently using them. General dentists practising in rural locations were more likely to have tried but abandoned rotary NiTi than metropolitan dentists ($\chi^2 = 6.174$, 1 df; $P = 0.01$), but there was no significant difference for endodontists.

Table 3 Details of nonusers of NiTi according to location

Location	*n*	Never tried	Tried but abandoned	Unknown
Metropolitan dentists	417 [16]	300 [11]	62 [5]	55
Rural dentists	123 [2]	75 [1]	29[a] [1]	19
Unknown	3	2	0	1
Total number of nonusers	543	377 (81)	91 (19)	75

Percentage values in parentheses; number of endodontists in square brackets.

[a]Significantly higher proportion of rural general dentists than metropolitan general dentists ($\chi^2 = 6.174$, 1 df; $P = 0.01$).

Respondents were asked to indicate reasons for not having tried NiTi or for having abandoned their use, by choosing as many as applied from a list of nine reasons. An 'other' category was provided as well, and it was found that these answers could be sorted into four more groups – 'lack of NiTi education and/or training', 'perform little or no endodontics', 'fear of perforating or extruding debris' and 'no reason'. Some of the 'other' reasons could actually be interpreted to belong to one of the original nine reasons. The authors together decided and agreed on the category into which the 'other' reasons were placed. This decision was based first on matching key words common to the main list and to the respondents' comments. Then, the authors sought key words from the remaining 'other' comments and sorted them into the four new groups. After this sorting process, Table 4a was produced, which lists in descending order, the reasons (key words) and the respondent details. The 543 nonuser respondents gave varying numbers of reasons – one (61%), two (20%), three (8%), four (9%), five (1%) and six (1%). None gave more than six reasons.

Although fragility (i.e. risk of fracture) and the expense of the instruments were a concern, overall, the main reason given for not using rotary NiTi was that they were perceived to provide no advantage over traditional techniques (Table 4a). Comparisons were carried out for each reason between those who had never tried rotary NiTi and those who had but had abandoned them. Significant findings were that general dentists who had tried but abandoned the instruments were more likely to state that the instruments were 'too fragile' ($\chi^2 = 14.029$, 1 df; $P < 0.001$), 'too difficult to use' ($\chi^2 = 5.896$, 1 df; $P = 0.02$) and 'too difficult to learn' ($\chi^2 = 12.408$, 1 df; $P < 0.001$). There were no significant differences between endodontists who had tried rotary NiTi and those who had not.

These data were then analysed for the two graduation year ranges that differed significantly in their use of rotary NiTi, that is 1981–1990 and 1991–2000 (Tables 2 and 4b). Only the statistically significant data are presented in Table 4b. A significantly higher proportion of the 1981–1990 graduates who did not use rotary NiTi gave the reason that the technique took too much time to learn ($\chi^2 = 5.296$, 1 df; $P = 0.02$). The finding of a greater proportion of the 1991–2000 graduates, indicating nonavailability of the technology, was highly significant ($\chi^2 = 17.343$, 1 df; $P < 0.001$).

Table 4a Reasons for nonuse of rotary NiTi in descending order, for all dentists

Reason	*n*[a]	Never tried	Tried but abandoned
No perceived advantage	197 (36) [10]	135 (36) [3]	36 (40) [7]
Too fragile	130 (24) [18]	77 (20) [4]	43 (47) [12]
Too expensive	106 (20) [5]	72 (19) [3]	21 (23) [2]
Not available	68 (13) [1]	61 (16) [0]	2 (2) [0]
Lack of education	64 (12) [2]	45 (12) [1]	9 (10) [1]
No/little endo	40 (7) [0]	29 (8) [0]	5 (5) [0]
Takes too much time to learn	36 (7) [4]	25 (7) [1]	7 (8) [3]
Too difficult to use	22 (4) [3]	11 (3) [0]	10 (11) [3]
Too flexible	16 (3) [2]	11 (3) [2]	5 (5) [0]
No reason	15 (3) [0]	14 (4) [0]	0 [0]
Too difficult to learn	14 (3) [0]	6 (2) [0]	7 (8) [0]
Too slow	12 (2) [4]	6 (2) [2]	5 (5) [2]
Complications[b]	5 (1) [1]	4 (1) [0]	1 (1) [1]
Number of respondents	543 [21]	377 [6]	91 [12]

Percentage values in parentheses; number of endodontists in square brackets.

[a]Includes 75 respondents who provided reasons but did not specify whether they had tried rotary NiTi or not. Many respondents provided multiple reasons.

[b]Included fear of perforation and fear of extruding debris.

Table 4b Statistically significant reasons for nonuse of rotary NiTi for the two differing graduation year ranges

Reason	1981–1990	1991–2000
Takes too much time to learn	17[a]	4
Not available	14	33[b]
Number of respondents	153	115

[a]Significantly higher proportion than 1991–2000 ($\chi^2 = 5.296$, 1 df; $P = 0.02$).

[b]Significantly higher proportion than 1981–90 ($\chi^2 = 17.343$, 1 df; $P < 0.001$).

Affirmative ('Yes') response to the use of rotary NiTi
One hundred and eighty-eight dentists (26%) indicated that they currently used rotary NiTi instruments (Table 1). Comparing rural and metropolitan dentists revealed no significant differences in proportions of dentists using or not using rotary NiTi. These 188 respondents were asked to complete the remainder of the questionnaire. For the remaining 38 questions, the overall mean item response rate was 94%, with a range of 46–100%, mode of 99% and median of 98%. These questions comprised 33 closed- and five open-format questions with mean response rates of 97 and 73%, medians of 99 and 83% and ranges of 85–100 and 46–94%, respectively. For the questions of Part B alone, the mean item response rate was 97%, with a range of 83–100%, mode of 99% and median of 99%.

Frequency of use Respondents had been using the instruments for various periods of time with similar numbers of users in each time period (Table 5). This table formed the basis for subsequent comparisons in order to determine how responses changed with increasing experience. Table 6 demonstrates the changes in the number of times per week that respondents used rotary NiTi. In this table, the 'Linear-by-Linear Association test' was carried out to evaluate the tendency for greater frequency of use to be associated with longer clinical experience. The result was highly significant ($\chi^2 = 14.18$, 1 df; $P < 0.001$).

Clinical situation Respondents used rotary NiTi for molar teeth (93%) and premolar teeth (87%), but a smaller number used them in anterior teeth (61%). More respondents used the instruments in curved canals (93%) rather than in straight canals (82%), but equal numbers used them in the coronal (90%) and in the apical part (90%) of the canal. These proportions did not change significantly neither in those with greater experience nor between general dentists and endodontists.

Table 5 Length of time of use of rotary NiTi

Period	Number of respondents
0–12 Months	54 (29)
13–24 Months	50 (27)
25–36 Months	38 (20)
Longer than 36 months	45 (24)
Total	187[a]

Percentage values in parentheses.

[a]One respondent did not indicate the period of use of rotary NiTi.

Table 6 Weekly frequency of use of rotary NiTi with experience (number of respondents)

Frequency (per week)	Up to 12 months	13–24 months	25–36 months	Over 36 months	Total
<1	7	9	4	6	26
1	11	7	1	1	20
2	13	5	5	3	26
3	9	6	5	6	26
4	4	8	5	6	23
5 or more	10	15	18	23[a]	66
Total	54	50	38	45	187

[a]Significant increase in frequency of use with longer clinical experience ($\chi^2 = 14.18$, 1 df; $P < 0.001$).

Technique Two questions asked were which instrumentation technique and which sequence of instruments respondents used. Multiple responses were possible as was the opportunity to specify 'other'. The majority of respondents used a crown-down (61%) or a modified crown-down technique (39%). A number of respondents (13%) used a combination of techniques depending on the case. However, 14% indicated that they used a step-back technique. Hand instruments, either stainless steel or NiTi, were sometimes used by 67% of respondents to prepare the apical part of the canal, while 30% used stainless steel Gates Glidden burs in the coronal part of the canal. Many of the respondents (48%) indicated that they used variable instrument sequences, depending on the clinical situation. It should be noted here that any apparent discrepancies in percentages between technique and clinical situation are because of respondents using multiple techniques according to the demands of the particular case before them. No significant differences were found between endodontists and general dentists in instrumentation technique or sequence of instruments.

A wide range of different motors were used to drive the instruments. The Tri Auto ZX (J.Morita Corporation, Kyoto, Japan) was used by 50% of respondents, 32% used one of the Dentsply (Dentsply Maillefer, Ballaigues, Switzerland) range of motors, while 23% used an 'other' variety of high and low torque motors. These figures include the 5% of respondents who indicated that they used or had used two types of motor. Of the 'other' group, 55% were air-driven reduction handpieces.

Instrument re-use Of the 188 respondents, most (70%) indicated that they thought two to five uses per instrument was appropriate, while six to ten uses were indicated by 19%. Only 12% indicated single use (8 endodontists and 14 general dentists) and 5% used the instruments until distortion occurred. Ten respondents ticked more than one box, and some of these people indicated that the answer depended on the file size and canal shape.

When asked what criteria were used when deciding to dispose of an instrument, 87% of 186 respondents indicated that they based it on their assessment of the instrument's serviceability, up to a predetermined maximum number of uses. Reasons for discarding instruments sooner included factors such as distortion, unwinding, decreased cutting efficiency and inability to be cleaned. A large number (84%) also based this decision on the predetermined number of uses as reported immediately above. Anatomical reasons, specifically curved and/or narrow canals, were indicated by 70% of respondents. Again, it should be noted here that any apparent discrepancy in percentages is because of respondents using multiple criteria when deciding when to dispose of instruments. Greater experience with rotary NiTi did not result in significant changes in the criteria for the number of uses. Endodontists were significantly more likely to include the criteria of curved canals ($\chi^2 = 19.526$, 1 df; $P < 0.001$), narrow canals ($\chi^2 = 9.523$, 1 df; $P = 0.002$), and unwound or distorted files ($\chi^2 = 6.037$, 1 df; $P = 0.01$) in deciding when to dispose of the instruments.

Retreatment A total of 70% of respondents undertook endodontic retreatment, and of these, 54% used rotary NiTi instruments to remove gutta-percha either always (15%) or sometimes (39%). Significantly greater proportions of endodontists than general dentists undertook retreatments ($\chi^2 = 13.242$, 1 df; $P < 0.001$) and used rotary NiTi instruments to remove gutta-percha ($\chi^2 = 4.671$, 1 df; $P = 0.03$). The range of file sizes used was 15–45, with a mode and mean size of 30. The taper range was 0.02–0.12, with a mode of 0.04. The range of r.p.m. used was 10–1250, with a mode of 250 and a mean of 364. A Linear-by-Linear Association test showed that there was a significantly greater likelihood of using rotary NiTi for removal of gutta-percha in retreatments with greater experience in the use of the instruments for both endodontists ($\chi^2 = 9.46$, 1 df; $P = 0.002$) and general dentists ($\chi^2 = 13.60$, 1 df; $P < 0.001$).

Part C. Issues associated with NiTi usage

For the questions of Part C alone, the mean item response rate was 97%, with a range of 83–100%, mode of 99% and median of 99%.

Procedural experiences in general

In this section, the questions relate to difficulties that respondents may have encountered when using rotary NiTi instruments, and also the benefits they have noted. Before investigating the experiences of respondents with file fracture in particular, respondents were first asked a broad question on a range of procedural problems they may have encountered. Of the sample, 142 (76%) respondents indicated that they had experienced one or more of the listed procedural problems (Table 7). The remainder (24%) did not indicate having experienced any of these problems. One procedural problem had been encountered by 40%, two by 31%, three by 15%, four by 9%, five by 4%, six by 1% and seven by 1% of respondents. The only statistically significant difference was that more endodontists than general dentists noted having experienced (or at least having recognized) canal ledging ($\chi^2 = 11.677$, 1 df; $P = 0.001$). When compared with manual instrumentation techniques with stainless steel instruments, high proportions of positive experiences with rotary NiTi were noted (Table 8). Of the 176 respondents to this question, 90% indicated more than one of these particular benefits. A significantly higher proportion of general dentists found canal preparation to be faster ($\chi^2 = 5.686$, 1 df; $P = 0.02$), whereas a significantly greater proportion of endodontists found that canal curvatures were maintained ($\chi^2 = 10.237$, 1 df; $P = 0.001$).

Instrument fracture

The question on instrument fracture (Table 9) revealed that 74% of respondents had experienced fracture of an instrument. Of these 138, 72% had fractured one to five instruments and 28% had fractured six or more. No significant difference was found between endodontists and general dentists in fracture experience. However, significantly more endodontists had fractured six or more instruments ($\chi^2 = 21.514$, 1 df; $P < 0.001$). All sizes of instruments had been fractured but most seemed to be of smaller sizes – 15 (35%), 20 (49%), 25 (49%), 30 (30%), 35 (18%), 40 (7%) and 45–90 (8%). Similarly, all instrument tapers had been fractured with the 0.04 taper instruments showing the most (65%).

The majority of these 138 respondents had experienced fracture of the tip of instruments (88%), while 20% reported fracturing the middle portion and only 7% fracturing the top part of instrument blades. Similarly, most respondents indicated that instruments fractured in the apical part of canals (82%), but 36% fractured in the middle and 13% in the coronal parts of canals. No significant differences were found neither in those with greater experience nor between endodontists and general dentists.

Reasons for instrument fracture were many and varied (Table 10), and most respondents (72%) gave two or more possible reasons. The choices given in Table 10 were based on a similar question by Barbakow & Lutz (1997).

Table 7 Number (*n*) of endodontists (E) and general dentists (GD) encountering each procedural problem

Problem	*n*	E	GD
Binding of the file in the canal	100 (53)	21	79
Ledging of the canal	85 (45)	26[a]	59
Transportation of the canal terminus	42 (22)	13	29
Straightening of curved canals	35 (19)	11	24
Canal perforation, other than stripping	18 (10)	5	13
Strip perforation of a curved canal	16 (9)	2	14
Excessive dentine removal	15 (8)	3	12
Number of respondents	188	37	151

Percentage values in parentheses.
[a]Significantly higher proportion than general dentists ($\chi^2 = 11.677$, 1 df; $P = 0.001$).

Table 8 Number (*n*) of endodontists (E) and general dentists (GD) indicating positive experiences with rotary NiTi compared with manual instrumentation with stainless steel instruments

Benefit	*n*	E	GD
Canal preparation is much faster	141 (80)	23	118[a]
Canal curvatures are maintained	128 (73)	33[b]	95
Final canal obturation is easier	127 (72)	22	105
Working lengths are maintained	116 (66)	22	94
Number of respondents	176	35	141

Percentage values in parentheses.
[a]Significantly higher proportion than endodontists ($\chi^2 = 5.686$, 1 df; $P = 0.02$).
[b]Significantly higher proportion than general dentists ($\chi^2 = 10.237$, 1 df; $P = 0.001$).

Table 9 Incidence of file fracture for endodontists (E) and general dentists (GD)

Number of files fractured	*n*	E	GD[a]
1–5	99 (53)	12	87
6 or more	39 (21)	19[b]	20
None	48 (26)	6	42
Number of respondents	186	37	149

Percentage values in parentheses.
[a]Two general dentists who had fractured instruments did not indicate how many.
[b]Significantly higher proportion than general dentists ($\chi^2 = 21.514$, 1 df; $P < 0.001$).

Table 10 Reported reasons for file fracture by endodontists (E) and general dentists (GD)

Reason	*n*	E	GD
Excessive pressure on file	85 (62)	21	64
Over-usage	59 (43)	7	52[a]
Complex root canal anatomy	50 (36)	16	34
Unknown	43 (31)	12	31
Incorrect insertion angle of file	26 (19)	5	21
No irrigant in canal	19 (14)	0	19[b]
r.p.m. too high	15 (11)	2	13
Patient biting on handpiece	12 (9)	3	9
Incorrect file sequence	10 (7)	1	9
Nonconstant speed of rotation of file	6 (4)	0	6
Number of respondents	140	31	109

Percentage values in parentheses.

[a]Significantly higher proportion than endodontists ($\chi^2 = 6.249$, 1 df; $P = 0.01$).

[b]Significantly higher proportion than endodontists ($\chi^2 = 6.252$, 1 df; $P = 0.01$).

The only differences between general dentists and endodontists were that significantly more general dentists believed that instrument fracture was because of their over-usage ($\chi^2 = 6.249$, 1 df; $P = 0.01$) or the lack of root canal irrigant during instrumentation ($\chi^2 = 6.252$, 1 df; $P = 0.01$).When asked about the management of the fractured portion, 32% of 103 general dentists responding to the question had referred the patient to an endodontist. Overall, the 134 dentists responding to this question reported 146 instances of attempting to remove fractured instruments. Of these instances, 27% of fractured files were retrieved, whereas 73% were not. No significant differences were found in retrieval and nonretrieval rates between dentists and endodontists.

When the fragment was not retrievable, 97% of 119 respondents indicated that they would obturate the root canal with the fragment *in situ* and review. Some (8%) of the respondents indicated that they would attempt to bypass the instrument and 5% would resort to surgery if symptoms were present. Again, there were no significant differences between dentists and endodontists.

Part D. NiTi education

For the questions of Part D alone, the mean item response rate was 87%, with a range of 46–99% and median of 99%.

These questions related to the instruction respondents may have had in the use of rotary NiTi instruments and techniques. A high proportion (73%) of respondents had attended one or more courses in the use of rotary NiTi. Of these 136 respondents, 64% attended courses run by dental supply companies, while only 30% had attended courses run by universities. A proportion of the respondents (33%) had attended courses run either privately or by various dental associations and societies. The numbers of people who had (53%) or had not (47%) used rotary NiTi instruments before the course were similar. When asked whether they had benefited from the course(s), 90% of 93 respondents indicated that they had. This was attributed to the hands-on component primarily but also because of the theory component. The 10% of respondents who did not benefit from the course indicated that they felt the course was too product oriented presenting the instruments as a panacea. Four of these referred to courses run by the dental trade and one run by a university.

Of the 174 respondents, 76% had practised on plastic blocks, and 67% used extracted teeth. Thirty-six dentists (21%), but no endodontists, did not practise on either plastic blocks or extracted teeth, but instead learned the technique in patients. Endodontists were significantly more likely than general dentists to have practised in plastic blocks ($\chi^2 = 5.467$, 1 df; $P = 0.02$) and extracted teeth ($\chi^2 = 5.168$, 1 df; $P = 0.02$).

Discussion

The interpretation of the results of questionnaire survey research rests firmly on the response rate and a representative sample size. Low response rates may invalidate the data (Tambor *et al.* 1993). Although a crude assessment of nonresponse bias may seem to validate low response rates, high response rates allow precise estimates and more detailed examination of the data (Locker 2000). The correct sample size and sample selection are equally important (Dillman 2000). The literature indicates that the minimum valid response rate is in the range of 75–80% (Gough & Hall 1977, Evans 1991). Hence, the overall response rate of 87% in this paper can be considered representative of all dentists practising in Australia, not only because it is so high but also because of the systematic stratified probability sampling method used and the calculated sample size. In addition, the very high item response rates for the questions further validate the data. Nevertheless, it is acknowledged that interpretation of any survey data must consider the possibility of incorrect answers because of factors related to questionnaire design, question wording and respondent factors.

Generally, the overall results of this questionnaire survey indicate a sensible approach to the incorporation of rotary NiTi instruments and techniques into endodontic practice. The multiple answers provided to many

questions indicate that dentists appreciate that clinical circumstances can direct the course and sequence of the instrumentation phase. Dentists were using the instruments more frequently with increasing experience, and 35% used the instruments five times or more weekly. This is considerably more than the 11% in the study by Barbakow & Lutz (1997) on Lightspeed instruments but may be because of the totally different instruments and technique. The instruments used by respondents in the present study did not include Lightspeed. The crown-down and modified crown-down techniques were most commonly employed but dentists often adapted the instrument sequence to suit the particular clinical situation. Many dentists (54%) used rotary NiTi for all tooth types, and this was comparable to the 60% studied by Barbakow & Lutz (1997). Most dentists used the instruments two to five times and based the number of uses on an assessment of the instrument's serviceability and also its size and the canal shape. General dentists were using the instruments in retreatments but less than endodontists were, presumably because more endodontists undertook retreatments. An interesting finding was the variety of motors used by respondents, which supports the research by Yared (2002) that air, very low torque, low torque and high torque motors were safe if used correctly.

More endodontists than general dentists were using rotary NiTi instruments, and the open-question data indicated that many dentists planned to use the instruments once matters of availability of the instruments and of training in their use were addressed. Overall, 22% of Australian general dentists were using rotary NiTi instruments at the time of this survey. Barbakow & Lutz (1997) found that 80% of 177 Swiss dentists had integrated rotary NiTi into their practices. Slaus & Bottenberg (2002) reported that despite a variety of new instruments and techniques, most Flemish general dentists still used conventional preparation and obturation techniques. Additionally, Hommez *et al.* (2003) reported that some 28% of 309 Flemish dentists were using rotary NiTi instruments although 26% combined the technique with hand instruments. Jenkins *et al.* (2001) believed that the use of hand instruments could be both physically taxing and time consuming, which they believed explained their finding that dentists who performed many root fillings tended to use handpiece-energized files. The finding in the present study that the numbers of respondents in each period of time of use of rotary NiTi were similar indicates a relatively constant number of dentists incorporating the new technology into their practices. Hence, the data indicate a steady rate of adoption of the new technology.

The significantly fewer respondents in the graduation range 1991–2000 using rotary NiTi instruments compared with 1981–1990 is difficult to explain. A possible factor may be nonavailability of the technology to younger dentists working as assistant dentists to more senior colleagues. Another possibility is that younger dentists may be focussed on perfecting their hand instrumentation technique before contemplating changing to new technology with its own inherent learning curve. Furthermore, a greater proportion of the 1981–1990 graduates considered that the technique took too much time to learn. Perhaps these dentists had progressed to a stage of being comfortable with their hand instrumentation technique and not keen to devote time to a very different concept and technique. These speculations indicate a need for further work in the area of adoption of new technology in endodontics and dentistry in general.

Of concern is the finding that dentists were giving negative factors as reasons for not having tried the new technology. The majority (81%) of dentists who were not using the technology had never tried the instruments, and their main reason was that they felt there was no perceived advantage to using the new technology. This, together with the beliefs that the instruments were too fragile and too difficult to use and learn, indicates that dentists may be accepting the opinions and experiences of other dentists. The negative influences may come from colleagues who have had bad experiences or perhaps from people in authority (educators and endodontists) who had themselves not yet embraced the technology. However, Table 4a indicates that 16% of those who had never tried rotary NiTi had no access to the instruments. Furthermore, an overall 12% of dentists not using rotary NiTi at the time of the survey indicated a lack of training and education as a reason, but they were otherwise positive towards the new technology. Many of these dentists would very likely adopt the new technology with suitable training as implied by the 80% of dentists in the study by Barbakow & Lutz (1997) who had integrated the new technology into their practices. Furthermore, the need for 'suitable' training is supported by the finding that 10% of dentists who had abandoned the use of NiTi did so because of lack of education. From the comments provided by respondents, it appears that dentists want hands-on courses that adequately cover the theory and are run by clinicians experienced in the technology. Another very important consideration for respondents was the cost of the instruments as indicated in Table 4a.

This questionnaire survey clearly demonstrates that dentists are well aware of the limitations of the new

technology. While dentists have discovered the benefits of rotary NiTi instrumentation, they acknowledge that there can be procedural problems as well. As indicated in the list of reasons for nonuse of rotary NiTi instrumentation, fragility of the instruments was a concern to respondents. However, when considering the list of procedural problems other than instrument fracture, it is encouraging that the main problem encountered was binding of the instrument within the canal. An unexpected finding was the significantly higher proportion of endodontists reporting ledging as a problem. A possible explanation is that general dentists may not have recognized the occurrence of ledging, although this is not supported by the lack of other significant differences and that a relatively high proportion of dentists reported the problem. It is more likely that there are other unidentified factors involved in the differences in clinical technique between endodontists and general dentists. A discussion of factors affecting the performance of dentists and endodontists in clinical situations is beyond the scope of this paper. Overall, the numbers of respondents experiencing each procedural problem (Table 7) can be considered low. In comparison, the numbers of respondents reporting positive experiences (Table 8) were relatively much higher. That 70% of the respondents believed that it was appropriate to use the instruments two to five times indicates a responsible approach particularly when 84% of respondents based instrument disposal on that number of uses.

Respondents who had abandoned the use of the instruments because of fragility (47%) presumably had experienced fractures. Of the dentists who were currently using the technology, most had experienced fractures (74%), and the list of possible reasons (Table 10) indicates that these dentists were trying to understand the mechanisms behind this. This list was based on the one presented by Barbakow & Lutz (1997) whose top three reasons were excessive pressure (25%), incorrect insertion angle (17%) and complex anatomy (15%). In comparison, the present survey found that incorrect insertion angle was the fifth most common reason for fracture and over-usage was second (43%). Over-usage in the Swiss study was reported by only 6% of their respondents (Barbakow & Lutz 1997). Again, the two instrumentation techniques are quite different, which makes direct comparison difficult. In 97% of instances in the present study, dentists would obturate and review the case if fragment retrieval was not possible, which demonstrates a conservative attitude presumably because of a perception that prognosis is favourable despite an instrument fracture. The questionnaire did not seek information about time of instrument fracture relative to the stage of root canal treatment, which may influence subsequent treatment decisions.

Based on these findings, it is reasonable to suggest that the majority of dentists who experience instrument fracture seek to understand why it happens and continue to use rotary NiTi instruments because they perceive that the advantages outweigh the disadvantages. This supports the finding by Barbakow & Lutz (1997) that 90% of the dentists in their survey would recommend the rotary NiTi technique to colleagues despite 76% having experienced fractures. The most commonly experienced benefit in the present survey (80%) was the faster preparation of root canals, while in the Swiss study 54% indicated that their canal preparations were quicker. It should be noted here that some of the percentages presented in that study (Barbakow & Lutz 1997) were erroneously based on all the returned questionnaires (177) rather than the 141 who were actually using the technology. This was a simple but unnoticed editorial process error (Dr Fred Barbakow, personal communication) that has been taken into account in the present paper. Also, in the Swiss study 76% found the technique easier and 82% found it safer, which compares favourably with the present study (Table 8). These data assume considerable importance in light of the recent finding that patients treated by endodontists were significantly more satisfied than those treated by general dentists mainly because of the shorter treatment time in the former case (Dugas *et al.* 2002). Hence, both the present study and the study by Barbakow & Lutz (1997) indicate that the new technology will be of major benefit once general dentists have become proficient in rotary NiTi techniques.

Despite the limitations of the instruments, dentists were taking steps to become familiar with the properties and behaviour of the instruments. The finding that 73% of respondents currently using rotary NiTi had attended at least one continuing education course in the use of the instruments supports this. Such courses enable dentists to update their theory and learn new techniques (Barbakow & Lutz 1997). Also, most dentists demonstrated due care and diligence by first practising in plastic blocks and/or extracted human teeth. That 64% of respondents had attended training courses run by the dental trade has both positive and negative implications. The positive side is that it highlights again that dentists are actively seeking out knowledge and instruction. Furthermore, the dental trade is being responsible in recognizing the need for instruction in the use of the new technology.

A negative aspect, as indicated by several respondents, is that some commercially run courses were perceived

to be biased and aimed purely at selling their product. This is a somewhat harsh indictment when considering that the companies, by definition, are in the business of selling their product, and also considering that they are taking the trouble to provide courses. From a different perspective, this finding may be indicative of a degree of caution surrounding a technology that has, as yet, not been widely adopted. However, it should be of great concern to universities that only 30% of respondents attended a university-run programme. At best, this finding implies that the universities are slow to acknowledge the need within the dental profession of training courses in the new technology. At worst, the universities may not be in tune with the needs of the dentist in private practice possibly because of relying on the opinions of experts who themselves have not been adequately informed. This survey shows clearly that there is a demand for NiTi education, which must be broad, unbiased and presented by clinicians with experience with the new technology as indicated earlier when examining the reasons for nonuse of rotary NiTi.

Conclusions

The very high overall response rate of 87% in this paper, together with the very high item response rates, for the majority of questions can be considered representative of all dentists practising in Australia. Generally, the results of this questionnaire survey indicate a sensible approach to the incorporation of rotary NiTi instruments and techniques into endodontic practice. This study clearly demonstrates that dentists are well aware of the limitations of the new technology, but were taking steps to become familiar with the properties and behaviour of rotary NiTi instruments. Although instrument fracture was a common experience amongst respondents, it was generally of low frequency and it did not deter dentists from using the instruments. These findings indicate a responsible attitude by an increasing number of dentists adopting a new technology that has clear benefits over traditional techniques. The responses indicate that further NiTi education and training is sought by dentists, and addressing the negative perceptions based on opinion should be an objective of that education.

Acknowledgements

The assistance and financial support of the following are gratefully acknowledged – the Australian Dental Association Inc.; Australian Society of Endodontology Inc.; Associate Prof. Ian Gordon of the Statistical Consulting Centre, University of Melbourne; Dentsply Australia (Pty Ltd.); Halas Dental Limited; the J.Morita Corporation; and the National Health and Medical Research Council of Australia.

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