

A survey of adoption of endodontic nickel-titanium rotary instrumentation part 1: general dental practitioners in Wales

IN BRIEF

- Provides an overview of the current provision of endodontic services by general dental practitioners in Wales.
- Alludes to the differences in protocol and methodology between NHS and private endodontic treatment provision.
- Notes the significant variation in training and practice between the dental settings and discusses the barriers to usage of contemporary endodontic instrumentation.

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Objective To assess adoption of endodontic nickel-titanium (NiTi) rotary technology by general dental practitioners and identify factors influencing its uptake. **Design** Postal questionnaire. **Setting** General dental practitioners working in Wales. **Methods** General dental practitioners (n = 584) were approached regarding their usage or otherwise of nickel-titanium rotary instrumentation during root canal shaping. The postal questionnaire took the form of an anonymous survey comprising 13 questions. These questions covered usage parameters, satisfaction, training issues and reasons for avoidance of NiTi instruments. **Results** The response rate was 71%. Nickel-titanium rotary instruments were used routinely by 67% of those responding practitioners. Principle factors cited as being implicated in the decision to not adopt NiTi use included cost (65% of responses), lack of training and the perceived risk of instrument fracture. **Conclusions** Over two thirds of dental practitioners in Wales use rotary NiTi endodontic technology with the majority having converted to such systems more than three years ago. There was, however, a significant disparity in NiTi usage between solely NHS practitioners (42%) and private practitioners (90%). Continued provision of high quality hands-on practical workshops may be of benefit in facilitating a positive initial NiTi experience in order to assist the transfer to these newer technologies.

INTRODUCTION

The NHS underwent significant remuneration reform on the 1 April 2006 with the aims of putting the local NHS in charge of commissioning local services, deciding where to locate new services and to provide dentists with the stability of an agreed annual income in return for an agreed level of patient care. This is measured through overall 'courses of treatment' (rather than individual items of treatment) and has simplified the patient charging system by introducing just three 'bands' linked to specific courses of treatment. The financial rewards for performing root canal treatment under this system fall into 'band 2' which equates to £47 in England¹ and £39 when undertaken in Wales.²

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Data from the UK-based National Health Service (NHS) Information Centre (<http://www.ic.nhs.uk/>) provides numerical data on courses of treatment undertaken by dental practitioners in England and Wales. Data for 2010/2011 show that in excess of 565,000 endodontic treatments were undertaken, a small increase of 3% on 2009/10. The estimated cost of such to the NHS was £26 million (based on a Band 2 fee of £47).

Root canal treatment is one of the most technically challenging clinical procedures and the quality of the treatment provided in general dental practice has been questioned.³ Saunders *et al.*⁴ found through a Scottish population study that 54% of the patient sample had at least one root filled tooth, that 5.6% of the teeth examined radiographically had root fillings, and of these, 58.1% had radiographic signs of periapical disease. Similarly Jenkins *et al.*⁵ found that a large percentage of practitioners had discarded those techniques taught during dental school and were using techniques with no evidence of clinical effectiveness. Grieve and McAndrew⁶ found that

from a total of 327 post-retained crowns examined radiographically 47% had areas of radiolucency around the root apices. A more recent study by Tickle⁷ demonstrated that 38.2% of NHS funded molar root fillings were suboptimal, although this surprisingly had no impact on failure rate.

These data are part of a growing body of evidence demonstrating, in most populations, a high frequency of technically defective root fillings, a high prevalence of periapical radiolucencies associated with root filled teeth and a strong correlation between the two.^{8,9}

Wu *et al.*¹⁰ summarised that histologically 50–90% of root treated teeth demonstrated apical periodontitis. This data is in contrast with a UK-study showing that within the data-set analysed (some 30,843 teeth root filled teeth over a period of 11 years), 74% of root canal-treated teeth survived 10 years without re-treatment, apical surgery or extraction.¹¹ This reveals a disparity between endodontic treatment standards and disease elimination and diagnosis. Despite these contrasting studies data would suggest the need

for improved standards of root canal treatment and coronal tooth restoration in an attempt to improve outcomes.¹²

Despite this high rate of substandard treatment few studies have been concerned with factors that influence the quality of root canal treatment performed in general dental practice. It might be assumed that such factors will relate not only to the individual dentist but also to the context in which they work. Certainly within the UK the dental NHS remuneration system, time-pressures, increasing patient expectations and inadequate technical equipment have all been expressed by general dental practitioners (GDPs) as having a bearing on treatment quality.¹³

The use of nickel-titanium alloys for endodontic instruments has increased since the developments reported by Walia *et al.*¹⁴ Nickel titanium alloys allow simplification of canal preparation procedure and increases efficiency.¹⁵⁻¹⁷ However, the uptake of NiTi by generalists (and in the case of this study UK-based GDPs) has rarely been measured. Similar dental technology paradigms have had their acceptance and impact recorded, an example being the dental operating microscope, a review of which was conducted by Selden.¹⁸

Certainly within Wales (with only one teaching dental institution) NiTi is the taught standard. Similarly this has been found in other European countries.¹⁹ Laboratory studies have described the shaping ability of different NiTi systems, indeed, there has been demonstration of nickel-titanium superiority over conventional instruments not only in their ability to provide an appropriate tapered funnel shape to the root canal (curved or straight) but in their ability to produce fewer preparation aberrations such as zips, ledges and perforations.^{16,17,20-23} Molander *et al.*²⁴ observed an increased frequency of good quality root fillings when a group of Swedish practitioners were trained to use a NiTi rotary system. Data from a recent retrospective study on 225 molar root canal treatments demonstrated periapical healing in 77% of teeth treated with rotary NiTi compared to 60% in the hand stainless steel file group; the group treated with rotary instruments also had fewer procedural errors.²⁵ There is also evidence that inexperienced operators such as dental undergraduates may achieve better prognosis at one year after treatment with NiTi

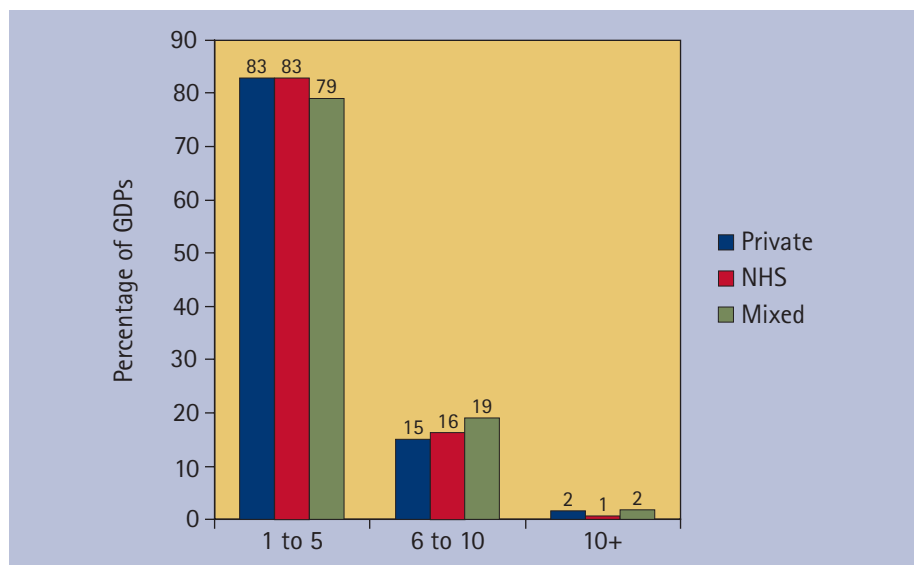


Fig. 1 Numbers of endodontic treatments performed weekly by contract type

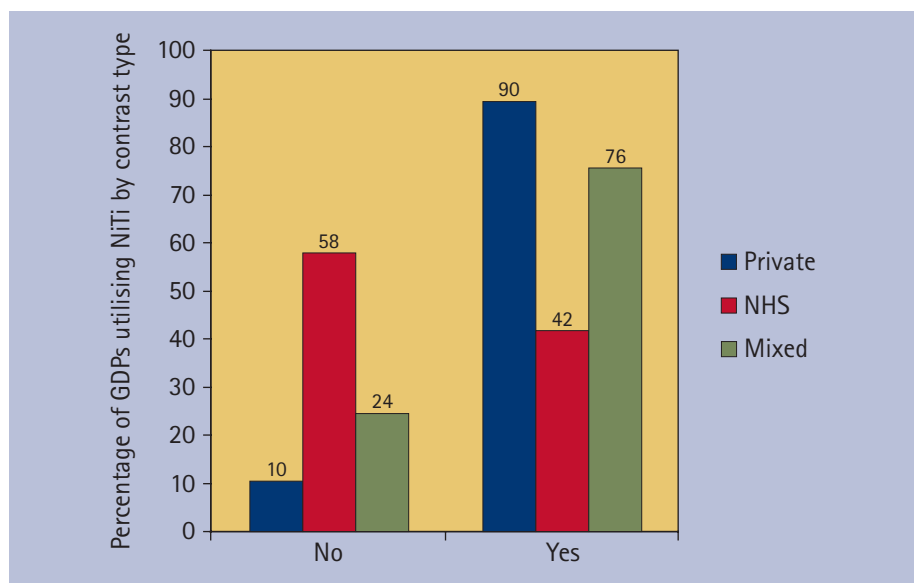


Fig 2 NiTi technology utilisation by contract type

hand-files when compared to the traditional stainless steel K-files, which was linked with the ability of NiTi to maintain the original canal shape after instrumentation.²⁶

Historically, endodontic treatments often extended to encompass multiple visits. More recently the trend has been to reduce this number; new endodontic technology implies fewer sessions and often allows treatment in a single visit, but perhaps more importantly recent studies have found that single visit root canal treatment may have comparable success rates to two visits.²⁷⁻²⁹

Although the viewpoint of academic teaching and endodontic societies would suggest NiTi as being the preferred method for canal preparation, little information is available regarding the attitude of dental

practitioners towards these recommendations and on how far the changes in endodontic technique have been incorporated into daily practice.

The aim of the present study was to (i) investigate the adoption of NiTi endodontic instrumentation among the National cohort of GDPs within Wales and (ii) determine the factors associated with uptake or avoidance of such adoption.

METHODS

A postal questionnaire was derived and piloted through staff members in a local district general hospital, a dental teaching school and with several local GDPs. Appropriate amendments were made, principally in reducing the number of questions (to 13) in order to encompass no more than

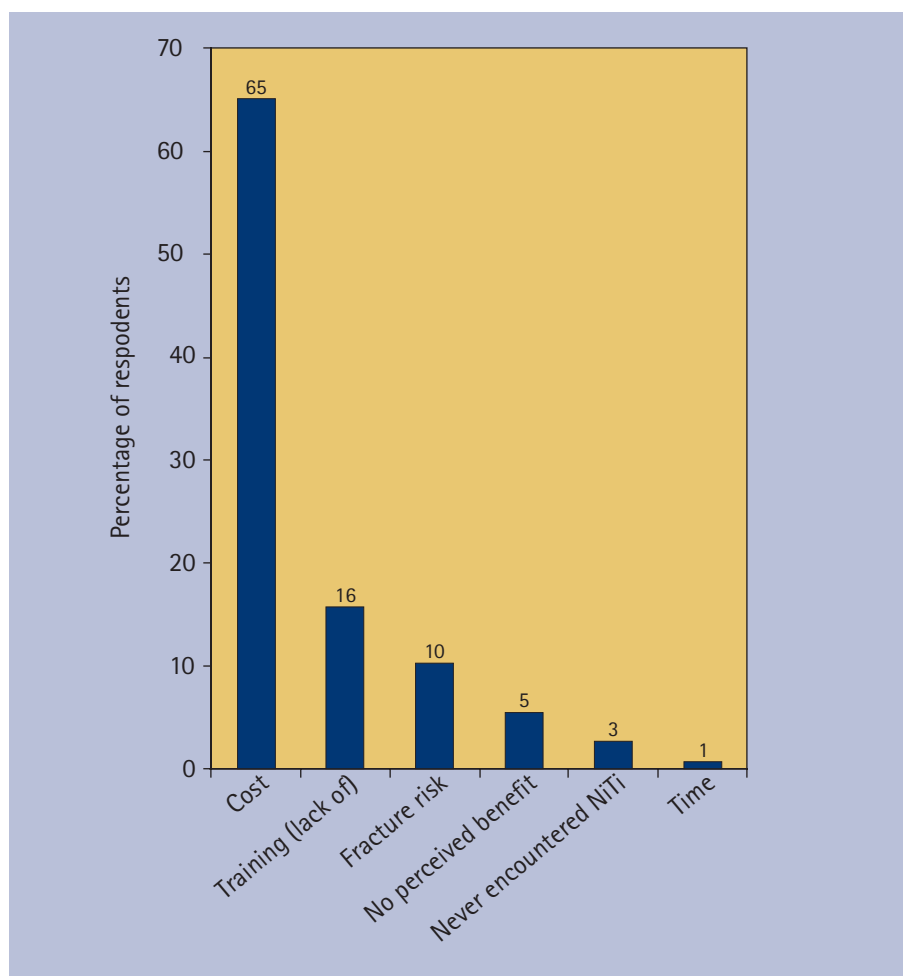


Fig. 3 Factors inhibiting uptake of NiTi technology

one page of A4. There were also minor alterations made to the running order. The compact nature of the formatting and the use of closed-questioning in the majority were introduced to increase compliance. Participants were given the option to opt out of answering the questionnaire. In addition, the second question screened for those dentists that did not undertake endodontic procedures. The second section comprised seven questions concerned with the practice setting, instrumentation usage and equipment/procedural training undertaken by the practitioner. The third and final section consisted of demographic questions.

In October 2010 the definitive postal questionnaire was delivered to all general dental practices in Wales using a practice address database held by the Welsh Dental Postgraduate Department. The postal questionnaire can be accessed in supplementary information.

The questionnaire began with an introductory explanation as to its purpose and emphasised its anonymity. Due to such anonymity a repeat sending of the

questionnaire was not possible. A post-reply envelope was included.

After a three month reply period data was collated and examined.

RESULTS

The results are given as absolute frequencies as well as percentages. Two replies were found to be from practices solely devoted to orthodontics so were removed from the study. Seven practices (1.2%) chose to opt out of answering the questionnaire. This left 403 appropriately answered questionnaires (69%), which were used for data analysis.

Question 1

Practitioners were asked whether they considered root canal treatment services to be in their remit. This question was primarily aimed toward those dentists working within the community dental service or hospital dental service, rather than GDPs, where specific job planning may preclude the provision of any endodontic treatments (data for this cohort published separately).

Question 2

Practitioners were questioned whether treatments were performed under NHS, private or a combination of both contracts. Fourteen percent ($n = 58$) of responses worked in the private sector only, 32% ($n = 129$) were working under the remit of the NHS alone and the majority of 53% ($n = 213$) provided mixed contract endodontic work.

Question 3

This question asked approximately how many root canal treatments were carried out on a weekly basis. Categories comprised 1-5, 6-10 or 10+ (Fig. 1).

On a contract basis it was apparent that very similar numbers of treatments were performed weekly with private practitioners (83%), NHS practitioners (83%) and mixed practitioners (79%), all performing between one and five treatments per week.

When data was grouped few practitioners (1.5%, $n = 6$) were performing in excess of ten treatments per week, two of these responders provided information that they worked as specialists in the field of endodontology, which would explain their higher throughput.

Question 4

This examined the numbers of practitioners that used (for the overwhelming majority of cases) nickel-titanium rotary instrumentation (Fig. 2). Again, data was divided into contract type. Ninety percent ($n = 52$) of private practitioners were using NiTi rotary technology compared with 42% ($n = 54$) of NHS practitioners. The mixed contract provided an approximate average at 76% ($n = 161$). When combined the data showed that 67% ($n = 267$) practitioners were using NiTi.

The data for those practitioners not undertaking use of NiTi (33%, $n = 133$) was then utilised in question five.

Question 5

Those practitioners not routinely using NiTi were then asked to provide reasons as to why this is the case. Predefined scenarios with check boxes were drawn up with the option to comment further if applicable. Multiple answers were allowed (Fig. 3).

Sixty-five percent of responses cited cost as being the prohibiting factor (interestingly only one such responder

was categorised as a solely private practitioner). Sixteen percent cited a lack of training and 10% were concerned with instrument fracture.

Other inhibitory factors such as 'no perceived benefit', 'time' and 'never encountered NiTi' received very few responses. Individualised written responses were few but overwhelmingly mentioned the perceived impossibility of utilising NiTi technology within the constraints of the NHS remuneration system.

Question 6

Returning to the cohort of practitioners that were utilising NiTi, question six enquired as to how many years such systems had been in use. Check boxes were included for 'less than 1 year', '1-3 years', '4-6 years' and '7+ years'. The majority of practitioners (92%, n = 245) had been doing so for in excess of three years.

Question 7

Responses were sought for the NiTi system manufacturer utilised. Multiple answers were accepted and eight popular systems provided as predesigned answers. An option was provided for alternate systems (Fig. 4).

Thirty-seven percent utilised the ProTaper® system (n = 103) and 31% (n = 85) the ProFile® system. The K3® system (n = 40) was the only other system that provided substantial responses. Within the section to provide alternate answers the Mtwo® systems (VDW) and HEROfill® (MicroMega) received several mentions each.

Question 8

Question eight attempted to ascertain whether practitioners utilised NiTi-based hand-files either, instead of, or as a supplement to the rotary system. When averaged a significant majority (69%, n = 184) did use NiTi hand files (Fig. 5).

Question 9

This enquired whether practitioners had either an interest in endodontics or perhaps a specific post-graduate qualification. Twenty-nine percent of private practitioners did express such an interest with 9% of NHS practitioners responding similarly. When data is combined one quarter of respondents did express such interest/qualification in endodontics.

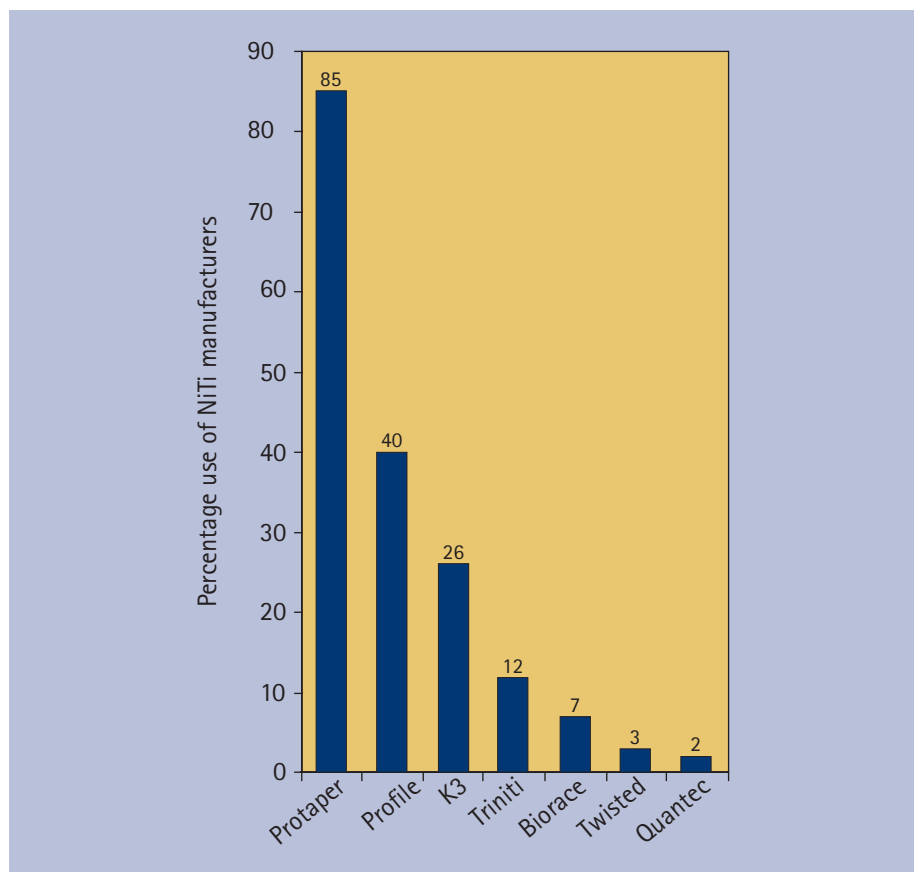


Fig. 4 NiTi usage by system

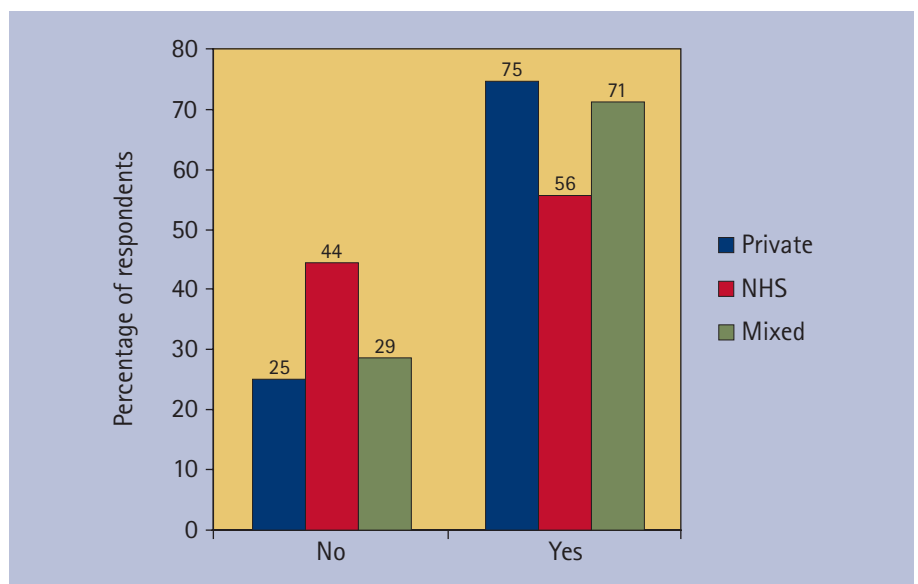


Fig. 5 Concomitant use of NiTi hand-files

Question 10

This question asked whether respondents had partaken in any form of postgraduate training in nickel-titanium rotary instrument usage. Seventy-six percent had (as high as 91% for private practitioners). Many responders commented that this was undertaken through Cardiff University Department of Postgraduate Medical and Dental Training. Other

popular answers stated training provided by specific instrument manufacturers.

Question 11

Enquired whether postgraduate training in the use of nickel-titanium endodontic instrumentation would be beneficial to the practitioners of Wales. A resounding 94% agreed that this would be beneficial.

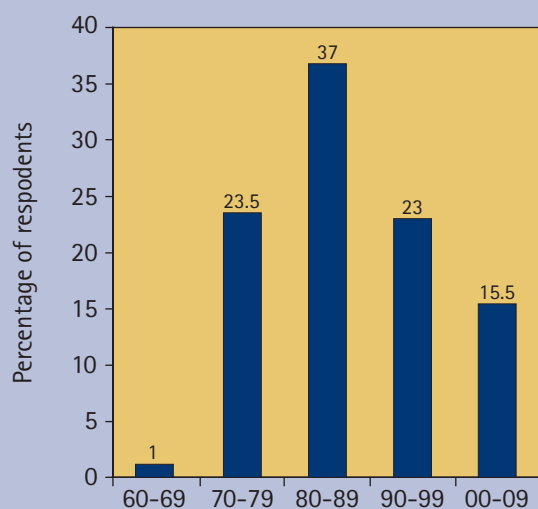


Fig. 6 Year of qualification

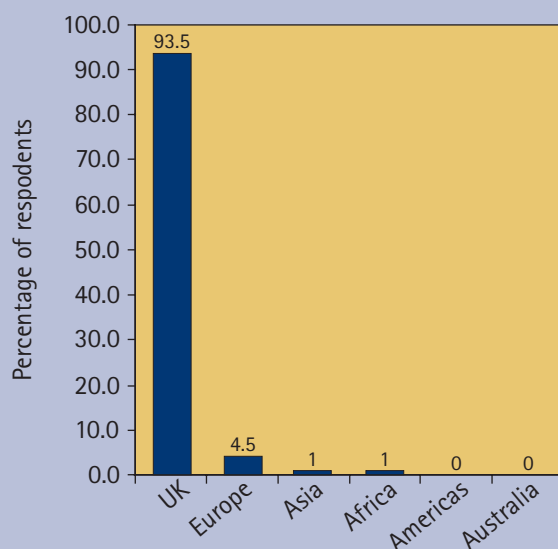


Fig. 7 Country of qualification

Question 12

The remaining two questions were of demographics. Question 12 determined the year of qualification (Fig. 6).

Question 13

Enquired as to country of qualification. In line with historical data the overwhelming majority (94%, $n = 375$) were of 'UK and Ireland' origin with few from mainland Europe, Asia and Africa (Fig. 7).

DISCUSSION

This study sought to collect data from all general dental practices in Wales on the uptake of NiTi endodontic instruments. Postal surveys provide a simple means of data collection and in this survey the response rate of 71% ($n = 412$ returns of

584 questionnaires) was encouraging and similar when compared to other dental postal questionnaires.³⁰ It is accepted that interpretation of survey data must take into account the possibility of participant bias.

Wales has a unique position in the UK both geographically and in its NHS health-care strategies. It is fortunate that data on practices and practitioners is held centrally within the Postgraduate Department of Medical and Dental Education as the only postgraduate dental teaching establishment in Wales (situated in the capital, Cardiff). This has allowed the authors an opportunity to investigate, as a whole, the endodontic practising methods of the nation's dentists.

The Dental Postgraduate Department has a long standing commitment to the training

and education of dental care professionals within Wales. There are 11 strategically positioned education centres comprising clinical skills laboratories that provide courses to GDPs for little financial outlay. Certainly there has always been a robust endodontic training section headed by specialists within Wales and with external links to established teachers in the field. The prospectus continually demonstrates courses with an endodontic theme including those with a 'hands-on' component. Indeed the questionnaire revealed a significant majority of practitioners (91% of private practitioners; 76% on averaging all practitioners) had undertaken postgraduate NiTi training through Cardiff University Department of Postgraduate Medical and Dental Education. This unique postgraduate set-up must be borne in mind before data can be compared with other national and international surveys on endodontic practice.

In the UK there are recognised postgraduate specialist training pathways in endodontology and restorative dentistry (that encompasses endodontology). However, with only 18 dentists in Wales registered with the General Dental Council's specialist lists as meeting the restorative or endodontic mono-speciality requisites, and a population of three million,³¹ the overwhelming number of endodontic treatments in adults in Wales are performed by GDPs within NHS or private practice arenas. Following this, with respect to question two and whether endodontic treatments were 'within the practitioners' remit' it is not surprising that just three responses (0.5%) were to the negative.

Data on NiTi uptake in general dental practice

The many written comments provided by NHS respondents provided much insight into the positive and negative aspects of performing endodontics (under the auspices of the NHS) in 2010. Sixty-seven percent ($n = 267$) of the responders reported the use of NiTi rotary instruments, a favourable percentage when compared to other studies by Slaus and Bottenberg³² and Hommez *et al.*³³ who among Flemish practitioners found 47% (of 1143 replies) and 50% (of 310 replies) respectively used NiTi at least sometimes. In an Australian survey by Parashos and Messer³⁴ it was

found that rotary NiTi instrumentation was used by 22% of general dentists (sample size 844). These somewhat low data are despite a growing body of studies showing benefits of NiTi instrumentation efficiency over conventional hand-filing.^{25,35,36}

The present study found that a majority of those not using NiTi reported cost as being the prohibitive factor (65%). Among general dentists negative attitudes towards root canal treatment have been reported, indeed Slaus and Bottenberg³² found that only 34% of a sample of Flemish dentists actually liked performing root canal treatments. The present study found on average one quarter of dentists had an interest in performing endodontics, a value similar to Hommez *et al.*³³ of Flemish dentists that found 25.7% having a clinical interest or speciality in practice.

Root canal treatment is technically demanding and is often carried out in less than optimal conditions in general dental practice. Several European population studies such as those of Kirkevang *et al.*³⁷ when investigating a Danish population, demonstrated poor endodontic outcomes by radiographic observation, (58% demonstrating inadequate lateral seal and 42% inadequate obturation length). Furthermore, 52% of the treated teeth (n = 773) were associated with signs of apical periodontitis.

It has been shown that GDPs in the UK frequently abandon endodontic protocols taught during dental school education for procedures that may not adhere to the recommended guidelines.⁵ More evidence exists for such abandonment of first principles with Slaus and Bottenberg³² and Lynch and McConnell³⁸ discovering that only 3% and 39% of Flemish and Irish practitioners respectively made use of rubber dam for endodontic purposes, despite studies having shown that most patients prefer dental treatment to be carried out under the protection of rubber dam.³⁹

The observed non-use of rubber dam and seemingly irrational endodontic treatment procedures might be due to the pressures of time resulting in short treatment session allowances. Such perceived pressures may be influenced by the restrictions imposed by the NHS remuneration system. In the UK the fee structure within the NHS has for many years not necessarily rewarded endodontic treatment quality and outcome,

principally because it has been fixed at a relatively low level. This aspect has been qualitatively analysed in the study by McColl *et al.*¹³ where in-depth interviews of GDPs revealed that there was a dilemma between the time required for molar root canal treatment and the fee offered by the NHS. This financial position was further eroded in 2007 by the Department of Health statement on single-usage policy of endodontic instrumentations in relation to potential vCJD infectivity.⁴⁰

In the light of a new fee structure, Danish dentists were recently motivated and encouraged to use rubber dam in order to produce high quality treatment.⁴¹ As already outlined, the remuneration system is only one aspect among many factors that affect the quality of root canal treatment performed in general dental practice but certainly there exist, and will remain, financial barriers to NiTi uptake for those dentists practising under the UK NHS remuneration schemes.

Practitioners should be given a compelling reason for adopting a new technology which relates to demonstrably more favourable outcomes in their management of oral disease.⁴² This may not be apparent when browsing the European Society of Endodontology updated quality guidelines which states that for canal preparation 'the apical constriction should be maintained, the canal should end in an apical narrowing and the canal should be tapered from crown to apex'.³ Indeed, the questionnaire and other studies have found a propensity for negative attitudes toward NiTi technology. The question of dentist's attitude to fracture of rotary endodontic instruments was broached by Madarati *et al.*⁴³ They found that both endodontists and GDPs were aware of the implicated factors contributing to endodontic instrument fracture. These were ranked from high to low as: operator experience, complexity of root canal anatomy and numbers of root canal procedures performed by such instruments. The questionnaire found that cost, lack of training and fracture incidence to be the major reasons for lack of uptake of NiTi.

Advantages of rotary NiTi

It is apparent that marketing has focused not so much on health effects as on enhancing the simplicity and the

timesaving effects of using NiTi technology. Although improved clinical outcomes with the use of rotary instruments is still not a universally conclusive finding within the endodontic literature there is evidence to suggest rotary instrumentation provides several advantages over previous hand filing techniques, in particular its efficiency and respect of canal anatomy.

A study by Pettiette *et al.*⁴⁴ compared stainless steel hand files with rotary NiTi; the use of the rotary instruments resulted in significantly less straightening of curved canals and a shorter preparation time. The results of that study also suggested improved radiographic success following the use of rotary NiTi instrumentation. This trend is also supported by the work of Cheung and Liu²⁵ who demonstrated fewer procedural errors when NiTi was used. Rotary instrumentation will produce canals of greater tapers that potentially lead to more mechanical removal of infected dentine and better irrigant penetration that is critical to disinfection procedures. Further, in the Australian survey by Parashos and Messer³⁴ 80% of the users of rotary instrumentation reported a more rapid preparation of root canals, less instrumentation sessions and fewer numbers of visits needed to complete a case.

Postgraduate training

The successful introduction of new technologies into routine clinical practice would appear to require not only effective products, but also the appropriate data and educational training to underscore their usefulness to practitioners.⁴² In a study of 702 UK-based primary dental care practitioners Palmer *et al.*⁴⁵ found that almost 25% of respondents had not received any teaching or training in endodontics in the past two years. A study of Swedish dentists by Reit *et al.*⁴⁶ found significantly more individuals willing to adopt a rotary endodontic system when hands-on training was included in the educational package, as compared with lectures and written information alone. In mirroring the findings of Reit the adoption of a new technology might be influenced by the design of an introductory educational programme. Certainly in the case of dental undergraduate teaching within Wales NiTi technology

has been incorporated into the curriculum for many years, an advantage for those dentists qualifying within the last decade but of course not for those who qualified beforehand.

Supervised and focused continuing education improves clinical skills and knowledge and helps delay declining clinical competence. Successful continuing education programmes should include individualised feedback, face-to-face assistance, objective setting and the use of opinion leaders as role models. Courses should be providing information as a means of reducing uncertainty about an innovation and focusing on how to control and direct the innovation. Educators must recognise that different people have different aptitudes and different skill levels.⁴⁷ For clinical procedures, such as root canal instrumentation, the inclusion of hands-on training sessions would seem to be important to reach a high acceptance rate.

CONCLUSIONS

Rotary NiTi endodontic technology has had an encouraging level of uptake within the cohort of GDPs of Wales within the private sector. It is true, however, that a new remuneration system instigated by the NHS appears to have a negative influence on uptake of this relatively new and certainly costly technology for strictly NHS practitioners. At the time of writing pilots are underway in England following the 'Steele' recommendations to alter the way dentists are remunerated.⁴⁸

Altered fee structure may influence uptake of newer technologies but without appropriate training may not result in increased clinical success. Quite how significant a factor adequate training is to the uptake is not clear but few would suggest that appropriately tailored, hands-on NiTi courses would not be advantageous. It is apparent that despite large numbers of practitioners already having partaken such courses they are vocal in their willingness to undertake additional training.

The adoption of new endodontic technology among GDPs within Wales is promising when compared to other somewhat older studies, but the current UK NHS remuneration system appears to have influenced the rate of adoption with the ramification that quality endodontics might be hindered by the non-use of NiTi

rotary instrumentation. Whether proposals for contract changes will have any impact on endodontic practices remains to be seen.

1. Department of Health. *NHS dental reforms: one year on*. London: DH, 2007. Online article available at http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_077238 (accessed January 2013).
2. Welsh Assembly Government. *NHS dental charges in Wales frozen for fifth year running*. Wales: Welsh Assembly Government, 2011. Online article available at <http://wales.gov.uk/newsroom/healthandsocialcare/2011/110223dentalcharges/?lang=en> (accessed January 2013).
3. European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. *Int Endod J* 2006; **39**: 921–930.
4. Saunders W P, Saunders E M, Sadiq J, Cruickshank E. Technical standard of root canal treatment in an adult Scottish sub-population. *Br Dent J* 1997; **182**: 382–386.
5. Jenkins S M, Hayes S J, Dummer P M. A study of endodontic treatment carried out in dental practice within the UK. *Int Endod J* 2001; **34**: 16–22.
6. Grieve A R, McAndrew R. A radiographic study of post-retained crowns in patients attending a dental hospital. *Br Dent J* 1993; **174**: 197–201.
7. Tickle M, Milsom K, Qualtrough A, Blinkhorn F, Aggarwal V R. The failure rate of NHS funded molar endodontic treatment delivered in general dental practice. *Br Dent J* 2008; **204**: 254–255.
8. Eriksen H M, Bjertness E. Prevalence of apical periodontitis and results of endodontic treatment in middle-aged adults in Norway *Endod Dent Traumatol* 1991; **7**: 1–4.
9. Dugas N N, Lawrence H P, Teplitsky P E, Pharoah M J, Friedman S. Periapical health and treatment quality assessment of root-filled teeth in two Canadian populations. *Int Endod J* 2003; **36**: 181–192.
10. Wu M K, Dummer P M, Wesselink P R. Consequences of and strategies to deal with residual post-treatment root canal infection. *Int Endod J* 2006; **39**: 343–356.
11. Lumley P J, Lucarotti P S, Burke F J. Ten-year outcome of root fillings in the General Dental Services in England and Wales. *Int Endod J* 2008; **41**: 577–585.
12. Ng Y L, Mann V, Gulabivala K. Tooth survival following non-surgical root canal treatment: a systematic review of the literature. *Int Endod J* 2010; **43**: 171–189.
13. McColl E, Smith M, Whitworth J, Secombe G, Steele J. Barriers to improving endodontic care: the views of NHS practitioners. *Br Dent J* 1999; **186**: 564–568.
14. Walia H M, Brantley W A, Gerstein H. An initial investigation of the bending and torsional properties of Nitinol root canal files. *J Endod* 1988; **14**: 346–351.
15. Tharuni S L, Parameswaran A, Sukumaran V G. A comparison of canal preparation using the K-file and Lightspeed in resin blocks. *J Endod* 1996; **22**: 474–476.
16. Schäfer E, Lohmann D. Efficiency of rotary nickel titanium FlexMaster instruments compared with stainless steel hand K-Flexofile – part 2. Cleaning effectiveness and instrumentation results in severely curved root canals of extracted teeth. *Int Endod J* 2002; **35**: 514–521.
17. Schäfer E, Erler M, Dammaschke T. Comparative study on the shaping ability and cleaning efficiency of rotary Mtwo instruments. Part 1. Shaping ability in simulated curved canals. *Int Endod J* 2006; **39**: 196–202.
18. Selden H S. The dental-operating microscope and its slow acceptance. *J Endod* 2002; **28**: 206–207.
19. Arab-Chirani R, Vulcain J M. Undergraduate teaching and clinical use of rotary nickel-titanium endodontic instruments: a survey of French dental schools. *Int Endod J* 2004; **37**: 320–324.
20. Bishop K, Dummer P M. A comparison of stainless steel Flexofiles and nickel-titanium NiTiFlex files during the shaping of simulated canals. *Int Endod J* 1997; **30**: 25–34.
21. Thompson S A, Dummer P M. Shaping ability of ProFile.04 Taper Series 29 rotary nickel-titanium instruments in simulated root canals. Part 1. *Int Endod J* 1997; **30**: 1–7.
22. Thompson S A, Dummer P M. Shaping ability of ProFile.04 Taper Series 29 rotary nickel-titanium instruments in simulated root canals. Part 2. *Int Endod J* 1997; **30**: 8–15.
23. Park H. A comparison of Greater Taper files, ProFiles, and stainless steel files to shape curved root canals. *Oral Surg Oral Med Oral Pathol Oral Radiol Endo* 2001; **91**: 715–718.
24. Molander A, Caplan D, Bergenholtz G, Reit C. Improved quality of root fillings provided by general dental practitioners educated in nickel-titanium rotary instrumentation. *Int Endod J* 2007; **40**: 254–260.
25. Cheung G S, Liu C S. A retrospective study of endodontic treatment outcome between nickel-titanium rotary and stainless steel hand filing techniques. *J Endod* 2009; **35**: 938–943.
26. Pettiette M T, Delano E O, Trope M. Evaluation of success rate of endodontic treatment performed by students with stainless-steel K-files and nickel-titanium hand files. *J Endod* 2001; **27**: 124–127.
27. Peters L B, Wesselink P R. Periapical healing of endodontically treated teeth in one and two visits obturated in the presence or absence of detectable microorganisms. *Int Endod J* 2002; **35**: 660–667.
28. Kvist T, Molander A, Dahlén G, Reit C. Microbiological evaluation of one-and two-visit endodontic treatment of teeth with apical periodontitis: a randomized, clinical trial. *J Endod* 2004; **30**: 572–576.
29. Figini L, Lodi G, Gorni F, Gagliani M. Single versus multiple visits for endodontic treatment of permanent teeth. *Cochrane Database Syst Rev* 2007; **4**: CD005296.
30. Tan R T, Burke F J. Response rates to questionnaires mailed to dentists: a review of 77 publications. *Int Dent J* 1997; **47**: 349–354.
31. Welsh Assembly Government. *Statistical directorate: Wales's population 2010*. Wales: Welsh Assembly Government, 2010. Online information available at <http://wales.gov.uk/topics/statistics/headlines/population2010/101027/?lang=en> (accessed January 2013).
32. Slaus G, Bottenberg P. A survey of endodontic practice among Flemish dentists. *Int Endod J* 2002; **35**: 759–767.
33. Hommez G M, Braem M, De Moor R J. Root canal treatment performed by Flemish dentists. Part 1. Cleaning and shaping. *Int Endod J* 2003; **36**: 166–173.
34. Parashos P, Messer H H. Questionnaire survey on the use of rotary nickel-titanium endodontic instruments by Australian dentists. *Int Endod J* 2004; **37**: 249–259.
35. Sadeghi S. Shaping ability of NiTi rotary versus stainless steel hand instruments in simulated curved canals. *Med Oral Patol Oral Cir Bucal* 2011; **16**: e454–458.
36. Gergi R, Rjelyi J A, Sader J, Naaman A. Comparison of canal transportation and centering ability of twisted files, Pathfile-ProTaper system, and stainless steel hand K-files by using computed tomography. *J Endod* 2010; **36**: 904–907.
37. Kirkevang L-L, Ørstavik D, Hørsted-Bindslev P, Wenzel A. Periapical status and quality of root fillings and coronal restorations in a Danish population. *Int Endod J* 2000; **33**: 509–515.
38. Lynch C D, McConnell R J. Attitudes and use of rubber dam by Irish general dental practitioners. *Int Endod J* 2007; **40**: 427–432.
39. Stewardson D A, McHugh E S. Patients' attitudes to rubber dam. *Int Endod J* 2002; **35**: 812–819.
40. Department of Health. *Primary care dental services: guidance on single-use instruments for endodontic procedures*. London: DoH, 2007. Online article available at <http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/>

- PublicationsPolicyAndGuidance/DH_074926 (accessed January 2013).
41. Bjørndal L, Reit C. The adoption of new endodontic technology among Danish general dental practitioners. *Int Endod J* 2005; **38**: 52–58.
 42. Barnett M L. Decisions, decisions: challenges to the introduction of new technologies to clinical practice. *J Dent Res* 2002; **81**: 5.
 43. Madarati A A, Watts D C, Qualtrough A J. Opinions and attitudes of endodontists and general dental practitioners in the UK towards the intra-canal fracture of endodontic instruments. Part 1. *Int Endod J* 2008; **41**: 693–701.
 44. Pettiette M T, Metzger Z, Phillips C, Trope M. Endodontic complications of root canal therapy performed by dental students with stainless-steel K-files and nickel-titanium hand files. *J Endod* 1999; **25**: 230–234.
 45. Palmer N O, Ahmed M, Grieveson B. An investigation of current endodontic practice and training needs in primary care in the north west of England. *Br Dent J* 2009; **206**: E22.
 46. Reit C, Bergenholtz G, Caplan D, Molander A. The effect of educational intervention on the adoption of nickel-titanium rotary instrumentation in a public dental service. *Int Endod J* 2007; **40**: 268–274.
 47. Parashos P, Messer H H. The diffusion of innovation in dentistry: a review using rotary nickel-titanium technology as an example. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006; **101**: 395–401.
 48. Department of Health. *NHS dental services in England: an independent review led by Professor Jimmy Steele*. London: Crown Copyright, 2009. Online article available at http://www.dh.gov.uk/dr_consum_dh/groups/dh_digitalassets/documents/digitalasset/dh_101180.pdf (accessed January 2013).

SUPPLEMENTARY INFORMATION

Postal Questionnaire

Dear Colleague

We would be grateful if you could spend a few minutes of your time contributing to this postal questionnaire which aims to evaluate the adoption of endodontic nickel-titanium rotary instrumentation by General Dental Practitioners within Wales.

The survey consists of 10 questions designed so that, in the main, you only need to tick boxes. For those questions with multiple answer choices please circle the most appropriate answer.

If you have no responsibility for the provision of endodontic treatments please indicate in question 1 and return the form, negative data is important to our study.

Please return questionnaires using the pre-paid envelop included.

All returned questionnaires are anonymous and no repeat mailings will be undertaken.

If there are any queries or require further information relating to the study please do not hesitate to contact us.

Kind regards

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A Survey of Adoption of Endodontic Nickel-Titanium Rotary Instrumentation by General Dental Practitioners in Wales.

If you would like to opt out of answering this questionnaire please tick here but we would be grateful if you would return the unanswered form for our data collection. Thank you.

1. If root canal treatment services are not within your remit tick here and return the unanswered form for our data collection. Thank you.
2. When performing your root canal treatments are they provided under:
 - NHS contract
 - Private contract
 - Both
 - Community / Hospital setting
3. Approximately how many root canal treatment treatments do you perform each week?
 - 1-5
 - 6-10
 - 10+
4. Do you routinely (for the overwhelming majority of cases) use nickel-titanium rotary instrumentation?
 - No (Please go to question 5)
 - Yes (Please go to question 6)
5. Please indicate if any of the options below are why you choose not use such instruments in your endodontic practice. Please elaborate if necessary.

Cost <input type="checkbox"/>	Time consuming <input type="checkbox"/>	Fracture concerns <input type="checkbox"/>
Lack of training <input type="checkbox"/>	No perceived benefit <input type="checkbox"/>	Never encountered NiTi <input type="checkbox"/> (Please go to question 10)

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6. For how many years have you used nickel-titanium rotary instrumentation?
<1 year
1-3 years
4-6 years
7-10+ years
7. If you have a preferred rotary system / manufacturer please would you specify?
ProFile® ProTaper® System GT® Quantec NiTi®
K3® BioRaCe® Triniti® Twisted Files®
Other
8. Do you ever use **hand** NiTi instrumentation instead of, or as a supplement to **rotary** (motor driven) instrumentation?
Yes
No
9. Do you have, by qualification or otherwise, a special interest in root canal treatments?
No
Yes
10. Have you partaken in any form of postgraduate training in nickel-titanium rotary instrument usage?
No
Yes
If possible please provide details:
.....
.....
11. Do you feel postgraduate training in the use of nickel-titanium root canal treatment instrumentation would be beneficial to the practitioners of Wales?
Yes
No

Clinician Details / Demographics

12. In what year did you qualify?
1960-1969
1970-1979
1980-1989
1990-1999
2000-2009
13. Country of Qualification?
UK and Ireland
Mainland Europe
Americas
Australasia
Asia
Africa

Thank you for your participation in the study
Please return questionnaires using the pre-paid envelop provided