

Direct pulp capping of permanent teeth in New Zealand general dental practice – A practice based research study

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ABSTRACT

Objectives: This study aimed to investigate treatment protocols and opinions towards direct pulp capping (DPC) amongst New Zealand (NZ) general dental practitioners (GDP) through a Practice Based Research Network (PBRN) study.

Design: Mixed-methods approach using qualitative thematic and quantitative analysis.

Methods: An on-line survey containing Likert scale items and open-ended questions was distributed to GDPs on the Dental Council of New Zealand (DCNZ) register (2012) to collect information on practitioner demographics, treatment protocols, continuing professional development (CPD) and philosophies towards DPC.

Results: Two hundred and ten GDPs from North and South Islands providing care in main centres and rural areas engaged with the PBRN and participated in the study. Almost all performed DPC treatment although it was not a common procedure. DPC was perceived as 'successful' or 'very successful' by 95% of respondents, mostly for cases of reversible pulpitis. Most provided DPC for patients of all ages but younger patients were perceived to have the best clinical outcomes. Calcium hydroxide and MTA were the most commonly used materials for DPC. MTA was believed to have the best outcome but cost and handling properties were barriers to its use. The majority of respondents had participated in CPD related to vital pulp therapy and regarded this treatment as conservative and providing time and financial benefits compared with more invasive treatment. Clinicians' timeframes for assessing healing were variable, and combined clinical and radiographic findings were considered most useful.

Conclusion: New Zealand dentists perceive DPC as a successful and conservative treatment in selected cases. The findings have provided insights into engagement of NZ dentists in using research to inform everyday clinical practice through a PBRN study.

INTRODUCTION

Pulp exposures are routinely managed by general dentists. Current practice recognises the healing potential of the pulp and advocates the use of vital pulp therapies in selected cases (Bjørndal et al., 2010; Aguilar and Linsuwanont, 2011). Direct pulp capping is one form of vital pulp therapy. It is conservative and an established technique that involves covering an exposed pulp with a dental material to protect it from further injury and promote healing (Nyborg, 1955; Shovelton et al., 1971; Nair et al., 2008). The ultimate goals of treatment are to maintain

pulp vitality, tooth function and survival. There are varied philosophies around DPC practices, materials and outcomes. Some of these are influenced by clinical experience or from results of studies, many of which have used different methodology and criteria for success or failure (Barthel et al., 2000; Dammaschke et al., 2010; Hilton et al., 2013).

Although treatment outcomes are dependent on the health of the pulp and absence of contamination, appropriate case selection is most important. The 'true' health of the pulp is difficult to accurately assess clinically and relationships between clinical findings and outcomes are not always predictable. Direct pulp capping is recommended following pulp exposures in previously asymptomatic teeth which show clinical signs and symptoms of reversible pulpitis and a normal apical appearance radiographically (Baume and Holz, 1981). Although clinicians are generally familiar with DPC treatment there is no data on how NZ dentists perform this and factors likely to influence their opinion of the technique.

Traditionally, there has been a translational gap or delay between what research evidence supports as best practice and what actually happens in everyday clinical dentistry (Curro et al., 2012). Practice based research networks are an established form of knowledge network where clinicians undertake research in collaboration with academic colleagues to generate meaningful research results directly relevant to their work environments. Evidence suggests that when practitioners are involved in developing research questions arising from their practice, the translational gap from research to practice is significantly reduced (Mold and Peterson, 2005).

In 2013 New Zealand's first dental PBRN, ARCH (Applied Research through Clinicians' Hands), was established. as part of the Clinical Research Group of the Sir John Walsh Research Institute (SJWRI), Faculty of Dentistry at the University of Otago. A symposium drew together academics and GDPs from across the country and resulted in the development of this inaugural PBRN project. Accordingly, this study aimed to explore the practices and opinions of NZ GDPs regarding the use of DPC treatment in permanent teeth by investigating treatment protocols, perceptions and opinions. A further objective of collecting this information was to assist in determining potential practitioner engagement in practice based research.

METHODS

A mixed-methods research approach involved administering an on-line survey instrument containing both quantitative and qualitative dimensions (Creswell and Plano Clark, 2007). Ethical approval was obtained from the University of Otago Human Ethics Committee (Approval Number 13/254) and Māori consultation was entered into with the Ngāi Tahu Research Consultation Committee.

To ascertain item validity, the survey was developed and piloted with a group of GDPs blinded to the study. The instrument contained Likert scale items as well as open-ended questions to provide context for triangulation and interpretation.

Qualitative data from these opinions and comments were used to corroborate and enhance the quantitative data. Questions assessed a range of variables relating to practitioner demographics, protocols and opinions about DPC treatment. To collect broad data, quantitative questions did not seek to split the use of DPC for carious and traumatic exposures, rather this was sought from qualitative questions that offered practitioners the opportunity to provide opinions and reasons for their responses. The survey also explored CPD related to pulp and endodontic therapies to assist in understanding how practitioners update their knowledge and understanding, and whether they had changed their techniques since graduation. It concluded with the invitation to register interest in joining the ARCH-PBRN and a link to the ARCH-PBRN website.

The survey was distributed in an on-line format (via an email link) to 1119 practitioners on the DCNZ register (2012) in the scope of general practice who had provided their contact email address. The email provided a short background on PBRNs and their objectives with an invitation to participate in the survey. The inclusion criteria were limited to general dentists practicing in the NZ private sector. Those recorded as 'not actively practicing' and specialists also registered in general dental practice were excluded, along with practitioners who had an email identifying them as associated with a government agency, university or district health board. There were various 'knock-out' points when an exclusion criteria was identified and so only those who met the inclusion criteria were able to fully complete the survey. Two weeks and four weeks after the initial survey a follow-up email was sent to potential participants to elicit further response.

Data from the survey were collated directly into Microsoft Office Excel 2010 (Version 14.01, Microsoft, CA, USA). Quantitative items were analysed using IBM SPSS Statistics software (Windows 2013, Version 22.0. Armonk, NY, USA). Following descriptive analysis, bivariate analysis was used to quantify differences in proportions using the Chi square test (X^2), while Spearman's rho (r_s) tested the strength of correlations. A general inductive descriptive analysis approach was employed to identify emerging themes from the qualitative data. Results of multiple data sources were then considered in light of the study objectives.

RESULTS

Demographics

Contact details were not available for 182 practitioners on the DCNZ (2012) database registered in the scope of general practice. From the email group of 1119, 210 survey responses were valid for the analysis (response rate 19%). The number of non-responders who met the inclusion criterion was unknown, however there were 53 addresses which were undeliverable and 11 out-of-office responses and these all remained so for the duration of the survey period.

Over 60% of clinicians who responded to the survey practiced in the North Island and respondents were geographically dispersed throughout NZ with responses from main centres and rural areas (Figure 1).

Most of the practitioners had graduated from the University of Otago (80%) and more than half prior to 1990. Almost two thirds of respondents were male and 45.2% were aged over 50 years. Graduates since 2011 made up 8.6% of respondents (Table 1). There was a significant relationship between gender and time of graduation ($p < 0.001$) with males making up 63.8% of

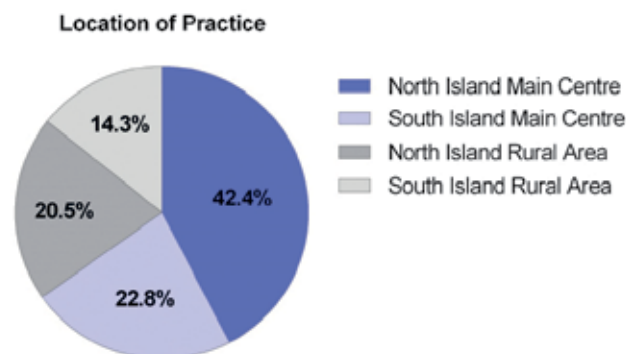


Figure 1: Pie graph showing practice location in New Zealand

Table 1: Demographic information of respondents

Practitioner Demographics		Number of respondents (%)
Sex	Male	138 (65.7)
	Female	72 (34.3)
Age (Years)	<25	15 (7.1)
	26-30	24 (11.4)
	30-40	30 (14.3)
	40-50	46 (21.9)
	50-65	71 (33.8)
	>65	24 (11.4)
Year of graduation	Before 1960	1 (0.5)
	1961-1975	34 (16.2)
	1976-1990	75 (35.7)
	1991-2000	36 (17.1)
	2001-2010	46 (21.9)
	After 2011	18 (8.6)
Country/region of graduation	University of Otago (NZ)	168 (80.0)
	Australian	2 (1.0)
	UK	15 (7.1)
	Asian	9 (4.3)
	European	2 (1.0)
	Other	14 (6.7)

those who had graduated prior 1990, while 69.4% of respondents who graduated after 1990 were female.

Direct pulp capping practices

The use of DPC by the respondents is shown in Table 2, indicating almost all practitioners undertook DPC in general practice, although it was not a common treatment procedure with over 80% of practitioners performing less than five DPC treatments per month. The majority had updated or changed the way they performed DPC since graduation in response to clinical experience and/or evidence-based understanding. An emerging theme from the qualitative data was the difference in the case selection, management and follow-up for pulp exposures due to trauma compared with those resulting from caries. There was a

preference by some practitioners to “avoid pulp exposure in the case of deep caries” and to perform step-wise caries removal with the placement of an indirect pulp cap “in order to stimulate healing”.

The majority (64.8%) of practitioners, regardless of the length of time in practice or clinical experiences indicated that patients of all ages were suitable for DPC treatment. Moreover, in younger patients maintenance of pulp vitality was identified as especially important, particularly for continued root development.

Respondents regarded case selection as significant when providing DPC treatment. Most identified tooth, patient and practitioner factors and deemed asymptomatic cases of reversible pulpitis as the most suitable for treatment. A typical response was “If a tooth was vital and asymptomatic with no periapical changes and the pulp was exposed when caries removal was mostly complete I would consider placing a direct pulp cap. The reasons for this would be because there is a chance of secondary/reparative dentine formation. The nature of the exposure (size, location, aetiology and length of time exposed to the oral cavity) was less commonly mentioned. The findings also suggested that the ability to preserve tooth structure, short treatment time and financial benefits were common reasons dentists performed DPC. It was seen as beneficial for patients because it was “conservative from a biological perspective”, “could be completed in one visit”, and was “cheap compared with root canal treatment”. Many practitioners indicated “full pulp removal could still happen later if necessary”. The financial cost of DPC compared with extraction did not appear to be a barrier to treatment with only 8.6% (n=19) of respondents indicating extraction would be a more favourable option because of cost. In addition, some respondents commented that “endodontic treatment and extraction are not comparable treatments” while others indicated that the similarity of costs

for both extraction and DPC, and the functional and biological advantages associated with tooth retention were important factors in planning treatment for patients. The cost of tooth replacement following extraction was also cited as an additional consideration that made DPC more favourable in the first instance. In contrast, the higher cost of root canal treatment was considered a contributing factor in deciding to perform DPC for 74.3% of practitioners. For a small number of respondents, health benefits remuneration for provision of root canal treatment to dental benefit patients was viewed as low for the clinical time involved and had financial implications.

A variety of different materials were placed on to an exposed pulp (Table 2). Calcium hydroxide (Ca(OH)₂) was used most commonly (36.7%) although nearly 30% of respondents preferred using mineral trioxide aggregate (MTA). Some practitioners had MTA in their surgeries, but did not use it consistently citing cost, handling and tooth discolouration as barriers to its regular use. About 20% of respondents routinely used Ledermix™ paste or cement material for DPC and the majority had adopted this practice after graduation. They viewed it as “the most effective material in symptomatic teeth” and “it reduced postoperative pain”. Glass ionomer cement (GIC) and other materials including resins were used less frequently. A small number of practitioners had recently adopted the use of Biodentine™ with some identifying challenges in its handling properties and extended setting time. Chi-square statistics showed a significant relationship between length of time in clinical practice and preferred pulp capping material ($X^2 = 37.7, p=0.01$) with responses to open-ended questions indicating respondents had updated or changed their treatment protocols. Many were using more contemporary evidence based materials or with clinical experience had assessed which materials provided the best outcome.

Table 2: Use of DPC in general practice

Practice		Number of Respondents (%)
DPC performed	Yes	207 (98.6)
	No	3 (1.4)
Number of DPC procedures per month	0	22 (10.5)
	1-5	155 (73.8)
	6-10	25 (11.9)
	≥11	8 (3.8)
Most common age of patients receiving a DPC	Under 15 years	15 (7.1)
	16-20 years	16 (7.6)
	21-30 years	25 (11.9)
	Over 30 years	16 (7.6)
	All ages	136 (64.8)
Material most commonly used for DPC	Ca(OH) ₂	77 (36.7)
	MTA	58 (27.6)
	Ledermix™	45 (21.4)
	GIC	23 (11.0)
	Other*	5 (2.4)

*Resins, Biodentine™

PERCEIVED OUTCOMES OF DIRECT PULP CAPPING TREATMENT

Over 95% of practitioners considered DPC to be successful or very successful and this was unrelated to length of clinical experience or how frequently this treatment was performed. Outcomes for DPC following traumatic exposures were perceived as more favourable than those placed as a result of caries and “teeth registered with Accident Compensation Corporation (ACC) tended to be reviewed regularly” while those that had undergone DPC following carious exposure were mostly reviewed if there was pain or as part of a patient’s annual examination. Practitioners mentioned the need for follow-up and review to assess healing although there was no consistent timeframe. A small number of practitioners indicated that “not hearing from the patient was an assumption that all was well and the treatment was successful”. The absence of clinical and radiographic signs and symptoms were almost universally identified as important for judging success and healing. Although responses varied, themes relating to pain, a periapical radiolucency and radiographic evidence of calcific bridge formation emerged as the most common indicators of healing or disease. Tooth survival and the “tooth not requiring extraction” were seen as important determinants for some practitioners while vitality and periapical health were priorities for others.

The survey sought to understand which material respondents perceived to have the best outcome and no criteria were set for participants as to what constituted success. The bar graph in

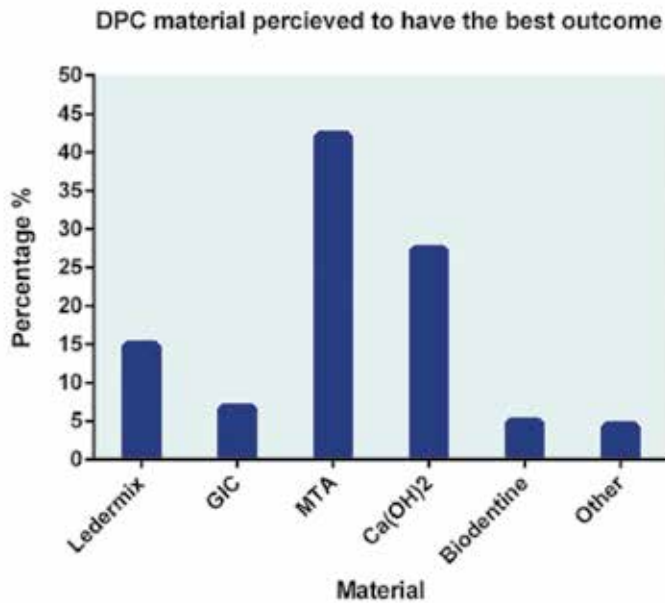


Figure 2: Bar graph showing the perceived success of DPC materials.

Figure 2 indicates MTA is believed to provide the best outcome for DPC by 42% of clinicians followed by Ca(OH)₂ (27.4%). One practitioner commented that “MTA has the best outcomes but I do not have access to it in my practice so for some cases I refer to practitioners I know use it”. There was a significant and strong relationship between the material normally used by the practitioner and that believed to have the best outcome ($r_s = 0.52, p < 0.01$).

CONTINUING PROFESSIONAL DEVELOPMENT

All respondents indicated they participated in CPD and this was mostly from attending conferences which involved interacting with colleagues. Gaining knowledge from published sources such as journals was the second most common modality while textbooks were used the least (Figure 3). Almost all respondents (92%) used on-line resources and the internet for CPD activities and 10% of practitioners (mainly recent graduates) used on-line CPD as the most common way to update their practice.

Overall, results indicate that over 85% of respondents had updated or changed their preferred protocol around DPC since graduation. Some of those who had not gave responses such as: “my current technique still works well” or “I know of nothing better”. These respondents included a small percentage (13.8%) of older practitioners who had graduated before 1975 and 25% of recent graduates (2011-2012). Modification of practice or technique by clinicians primarily involved changes in materials used for DPC. Many were aware of, or were using contemporary materials such as MTA and Biodentine™ but others (often recent graduates) had adopted the use of established materials especially Ledermix™. Those respondents who used Ledermix™ mostly cited its ease of availability in the practice and clinical reasons related to pain or a desire to delay root canal treatment. In contrast, those who had changed to contemporary materials such as MTA and Biodentine™ had done so in response to research evidence around pulp healing and the formation of reparative dentine.

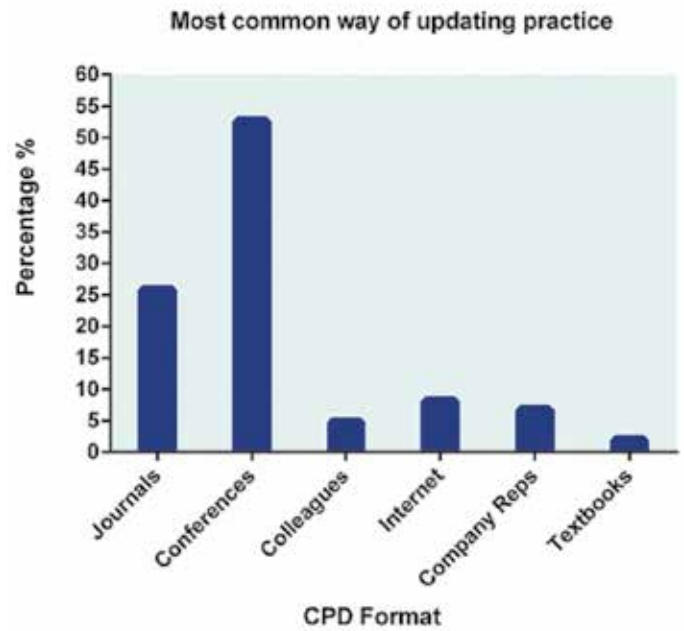


Figure 3: Bar graph showing how practitioners engage in CPD to update practice related to pulp therapy.

PRACTITIONER INTEREST IN A PBRN

Over half of the respondents indicated that they would like feedback on the results of this study and expressed an interest in joining a PBRN network. This group was geographically dispersed throughout NZ, included practitioners with a range of clinical interests, and several who had obtained undergraduate degrees outside of NZ.

DISCUSSION

There is a lack of NZ data on use and opinions associated with DPC and as such an aim of this study was to investigate clinical protocols and philosophies surrounding the use of DPC in this country and to establish a foundation necessary for engaging clinicians and academia in practice based research.

An increased participation rate would have been desirable, however on-line questionnaires are rarely associated with high response rates. The 18% participation rate appears low, however this value should be viewed with caution as the true number of eligible participants is unknown. This is because the DCNZ database also included those GDPs involved in non-clinical work, seeking employment, on parental leave, the recently retired or those who were no longer actively practicing, those who had changed email addresses, or had moved overseas but maintained registration. Despite this, the study engaged over 200 dentists from throughout NZ in practice based research. Moreover, this response rate was greater than studies using similar methodology (Aitken et al., 2008; Kogelman et al., 2014) and certainly beyond the minimum 10% threshold number (120) required in most clinical and behavioural studies (Rattray and Jones, 2007). The on-line survey only captured practitioners who had provided current email addresses however, the cost-effectiveness, completeness and quality of data collected from on-line questionnaires as well as their ability to engage younger practitioners have been highlighted as important reasons for their use (McMahon et al., 2003; Leece et al., 2004). These findings are

especially relevant to the development of the ARCH-PBRN and indicate that other modes of communication including postal mail, regional/practice visits and conference presentations are necessary for identifying potential practitioners to engage in the network.

It is important to consider the extent to which the findings from this sample are generalisable to NZ general practice. The demographic data identified similarities to the NZ dental workforce (2009) with respect to gender, practice location and university of graduation (Broadbent, 2011). The age of practitioners in the sample tended to be older and reflects the findings of international PBRNs where more experienced practitioners who are familiar with the longer term benefits of these networks in improving patient care are the most active. However, almost a third (30.5%) of the sample had graduated after 2000 and given the mobile nature of younger practitioners this suggests that the study respondents can give an insight into DPC practices in NZ.

The use of a mixed methods approach combining quantitative and qualitative forms of enquiry (Creswell and Plano Clark, 2007) enabled collection, analysis and integration of findings to provide richer data and deeper understanding of DPC in New Zealand than either method alone. The qualitative findings provided context to responses which was important in informing how clinicians manage deep caries and pulp exposures. Retrospective studies demonstrate poorer outcomes following carious exposures compared with trauma (Baume and Holz, 1981; Al-Hiyasat et al., 2006) and the current findings indicate that this may also be the case in the NZ dental healthcare setting. In some cases of deep caries, step-wise caries excavation without pulp exposure was frequently preferred by NZ clinicians and is consistent with evidence based clinical trials which have shown improved outcomes in selected cases for step-wise caries excavation compared with DPC for patients over 18 years-of-age with reversible pulpitis (Bjørndal et al., 2010). Further research enabling closer investigation of the management and outcomes of carious and traumatic pulp exposures in New Zealand is warranted, especially in regions identified as being populated by high caries-risk individuals.

International population studies have identified cost as a barrier to patients receiving treatment for pulp disease (Richardson et al., 2013; Thompson et al., 2014) and this appears similar in NZ. The results have shown that although clinicians understand the importance of appropriate case selection for use of DPC, when there are indications for more invasive management the reduced cost of DPC often makes it a favourable first option for patients. Health benefits remuneration was also an emerging theme for a small group of respondents who perceived the low remuneration as a barrier to providing step-wise caries removal or root canal treatment to school age children. Owing to the need for multiple appointments that did not always accrue a fee, there were tendencies to *“try other things first that were less invasive and financially more viable”* suggesting that treatment planning decisions by NZ practitioners may be influenced by things other than the health of the pulp and its capacity for healing. Further dialogue with NZ dentists is warranted regarding this and may inform health policy and remuneration for management of deep caries in younger patients.

Despite older teeth tending to have higher restorative experiences and undergoing physiological changes it appears that the majority of NZ dentists are providing DPC treatment for patients of all ages but younger patients are perceived to have the most favourable outcomes. This concurs with laboratory and clinical studies that have shown age is not a barrier to treatment (Baume and Holz, 1981; Al-Hiyasat et al., 2006; Bogen et al., 2008; Mente et al., 2010) but health of the pulp, vascularity, absence of contamination and coronal seal are most important for healing (Barthel et al., 2000). Moreover, the greater number of stem and progenitor cells in pulps of younger people infers better regenerative potential for healing, apexogenesis and root maturation (Friedlander et al., 2009).

This study has shown that Ca(OH)_2 was the most commonly used material for DPC because of low cost, ease of use and those using it believed *“it worked”*, however nearly a third of respondents were using MTA in response to evidence based knowledge. Calcium hydroxide has high antibacterial properties and for several decades it was considered the gold standard material for DPC (Nyborg, 1955; Baume and Holz, 1981). Long-term studies have shown variable but clinically acceptable results (Dammachke et al., 2010) but it is now known Ca(OH)_2 may be irritant to pulp tissue, have poor adhesive properties, and its soluble nature means it can be washed away over time leaving a void beneath a restoration. Tunnel defects have also been described in the reparative dentine bridge beneath the material which infer porosity and may enable penetration of microorganisms to the underlying pulp tissue (Cox et al., 1996). Mineral trioxide aggregate is now considered the gold standard material for DPC. It overcomes many of the disadvantages of Ca(OH)_2 with excellent antibacterial and sealing properties. It sets in the presence of moisture and the hard tissue barrier formed at the site of the exposure resembles a scar tissue made by pulpal fibroblasts (Ricucci et al., 2014). However, although NZ practitioners were aware of MTA and many were using it, respondents also identified the known drawbacks and barriers to its use including its high cost, handling difficulties and potential for tooth discoloration (Parirokh and Torabinejad, 2010). Biodentine™ is a relatively new silicate cement with similar efficacy to MTA for DPC however with the disadvantage of an extended setting time (Nowicka et al., 2013) and this was identified by a small group of respondents who were routinely using it for DPC.

The success rate for DPC is generally high but varies between studies depending on pulp health at the time of placement, the criteria for success, and the length of follow-up (Barthel et al., 2000; Aguilar and Linsuwanont, 2011). In the present study almost all clinicians considered this procedure to be successful or very successful and MTA was perceived to have the best outcome. Even if practitioners did not use the material many recognised its benefits and were familiar with its reported clinical outcomes (Bogen et al., 2008; Mente et al., 2010). The superiority of MTA over Ca(OH)_2 has been highlighted in a recent PBRN randomised clinical trial which compared Ca(OH)_2 with MTA for DPC and found the clinical and/or radiographic failure at two years for Ca(OH)_2 was 31.5% compared with 19.7% for MTA (Hilton et al., 2013).

The guidelines for assessing healing following vital pulp therapy state teeth treated by DPC should be followed up clinically and radiographically for two years (European Society of Endodontology, 2006). In the present study respondents commented on the need for a review following DPC, however they have not clearly suggested any specific timeframe, although trauma cases were more likely to have a specific review. Practitioners appear to be following international guidelines and use multiple criteria for judging healing. For the small number of respondents who mentioned tooth “survival” or “not needing an extraction” as success it is unknown if this was related to dentist or patient criteria.

Continuing professional development has been a requirement for NZ dentists’ continued registration since 2006. It aims at keeping practitioners up to date with best practice and over 85% of respondents had changed their protocols for vital pulp therapy and DPC since graduation. Those who had not changed tended to be recent graduates who felt their practice was still valid, or were older practitioners. Similar observations have been made in the United Kingdom and Europe where older practitioners tend to engage in CPD to fulfil professional body requirements, and activities tend to be convenience or interest driven (Buck and Newton, 2002; Barnes et al., 2013). Recent graduates on the other hand tend to engage less in structured CPD due to mounting clinical commitments and debt incurred from education (Leggate and Russell, 2002). The internet and e-learning are common methods of dental CPD and especially among younger dentists (Barnes et al., 2013) and with nearly 10% of respondents using on-line sources as their most common form of CPD this indicates the importance of on-line engagement for the ARCH-PBRN.

One of the objectives of PBRN research is to provide results that are meaningful for everyday clinical practice by collaboration between academics and clinicians (Curro et al., 2012). This study has engaged NZ dentists in a PBRN. Further research and modes of engagement are now necessary to involve those practitioners not contactable on the DCNZ (2012) database and those providing care to mainly Māori and underprivileged groups in order to provide richer data and further inform health policy around clinical practice.

CONCLUSION

This study has provided an important insight into DPC practices in NZ. It has found that DPC is practiced almost universally but is not common. It is believed to be a successful treatment in reversible pulpitis but practitioners frequently avoid complete pulp exposures in favour of indirect pulp capping. The conservative nature and relatively low financial cost makes DPC favourable to more invasive treatment. Calcium hydroxide is the most commonly used material for DPC followed by MTA, which was perceived to have the best outcome. Most practitioners had engaged in CPD related to vital pulp therapy and had updated or changed their practice of DPC since graduation and this was mainly due to changes in evidence-based knowledge or related to clinical practice philosophies.

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