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Validation of the effectiveness of the Dental Practicality Index in predicting the outcome of root canal retreatments

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Abstract

Aim

To assess the effectiveness of the Dental Practicality Index (DPI) in predicting the outcome of root canal retreatment in posterior teeth.

Methodology

One hundred and thirty-seven posterior teeth with symptoms and/or signs of endodontic post-treatment disease requiring root canal retreatment and previously included in a clinical trial were selected. Clinical and radiographic examinations including digital periapical and cone beam computed tomography (CBCT) were obtained pre-treatment and 1-year post-operatively from a previous study. Two calibrated and trained assessors who were unaware of the treatment outcome assessed the pre-treatment clinical records of these cases using the DPI. The DPI score was then compared to the outcome of the root canal retreatment. A Chi-square/Fisher's exact test was used to establish a relationship between categorical variables, the total score of DPI vs outcome.

Results

Re-treated teeth with DPI scores equal to 6 or above had an unfavourable outcome of 50% vs 14% of teeth with DPI below 6. Teeth with DPI score equal to 3 or above had an unfavourable outcome of 23% versus 2%, for teeth below 3. Molar teeth with a DPI score below 3 had a favourable outcome percentage of 96%.

Conclusions

This study highlighted that using the DPI gave a good outcome prediction for root canal re-treatments. However, further research, including the prospective assessment of a wider range of cases undertaken by a larger group of examiners is needed to further validate the DPI.

Introduction

Tooth survival is most often determined by local factors for example root filled teeth are generally associated with a shorter survival time compared to teeth with vital pulps (Ng *et al.* 2010). The periodontal status and structural integrity of the tooth may impact on tooth survival (Ng *et al.* 2011). Finally, the 'context' of treatment needs to be considered in relation to local and general factors, including the state or, or absence of nearby teeth, and/or health-related issues which many broadly influence treatment. It has been reported that local factors such as parafunctional habits, and general factors such as complex medical histories can adversely affect tooth survival (Cavel *et al.* 1985, Gulabivala 2004, Mindiola *et al.* 2006). The dental factors (endodontic, periodontal and structural integrity), as well as the context need to be assessed to determine whether a tooth should be treated or extracted and where indicated replaced with an implant retained crown or a fixed bridge.

The amount of residual tooth structure is one of the most important parameters determining the survival of (re-)treated teeth (Reeh *et al.* 1989, Gulabivala 2004, Creugers *et al.* 2005, Nagasiri & Chitmongkolsuk 2005, Ng *et al.* 2006, Al-Nuaimi *et al.* 2017). Teeth diagnosed with

endodontic disease often lack structural integrity and are compromised as a result of caries, existing restoration(s), cracks and fractures (Larson *et al.* 1981, Eakle *et al.* 1986, Tan *et al.* 2006). In addition, endodontic access cavity preparation results in further removal of sound structure, further weakening the tooth (Krishan *et al.* 2014, Moore *et al.* 2016).

The quantity of residual coronal structure also affects the quality of the coronal seal provided by the restoration placed on root filled teeth, which in turn is likely to affect the outcome of root canal treatments (Ray & Trope 1995, Kirkevang *et al*. 2000, Tronstad *et al*. 2000). A recent cone beam computed tomography (CBCT) outcome study revealed that at 1-year follow-up, the proportion of unfavourable outcomes of re-treated teeth was significantly greater when there was less than 30% of sound tooth structure present at the time of root canal treatment (Al-Nuaimi *et al.* 2017).

Several medical conditions may have an impact on the outcome of root canal treatment, for example diabetes and a history of systemic steroid therapy has been reported to resulted in a greater chance of teeth extraction after root canal treatment (Ng. *et al.* 2011). There is also evidence indicating that patients with diabetes have increased periodontal disease in endodontically involved teeth and have a reduced success rate of the root canal treatment in cases with preoperative periradicular lesions (Fouad & Burleson 2003, Arya *et al.* 2017, Cabanillas-Balsera *et al.* 2019).

Assessing the restorability and formulating a treatment plan for a tooth in need of root canal treatment is based on clinical and radiographic findings; however, the final treatment plan may well vary between dentists (Messer 1999, Alani *et al.* 2011, Rodríguez *et al.* 2017).

Several indices and guidelines have been suggested to help in case assessment. Some of the indices are designed to assess the difficulty of root canal treatments. These include the Dutch Endodontic Treatment Index (Ree *et al.* 2003), University of North Carolina Case Assessment (Pothukuchi 2006, Curry 2009), and the Canadian Academy of Endodontics Case Classification (2016). Major drawbacks of these indices include the lack of validation and the fact that they often focus on only one or two clinical or radiographic aspects of the overall restorative challenge.

For example, a classification to quantify the remaining tooth structure of root filled teeth was published by McDonald & Setchell (2005), but this did not consider the endodontic or the periodontal status of the tooth. The American Association of Endodontists (2010) published guidelines for evaluating the difficulty of endodontic cases with the aim of assisting dentists in deciding when to treat and when to refer teeth with endodontic problems. However, this guideline was reported to be used by only 10% of general practitioners in the USA as it was considered by many to be too exhaustive and time-consuming (Curry 2009).

The 'Dental Practicality Index' (DPI) (Dawood & Patel 2017) considers the practicality of restorative treatment. Each of the restorative categories - endodontic state, periodontal state, and structural integrity are assessed and weighted. Importantly, local and general factors and the context of the treatment are also considered. This includes the state of, or absence of nearby teeth, and the social, dental, and medical history. The endodontic state, periodontal state, structural integrity and the overall context are evaluated and scored as '0' if no intervention is required, '1' if simple treatment is required, and '2' if the treatment needed is more complex, for example where specialist referral is required. A score of '6' suggests that treatment would not generally be considered practical. After scoring each category, the sum of scores is then used to determine the DPI score. A DPI score ≥ 6 indicates that attempting to restore the tooth may not be advisable and other treatment options should be considered and discussed with the patient (Table 1).

To date, there is no evidence on the ability of restorative indices to predict the outcome of root canal retreatments or the survival of root filled teeth. The aim of this study was to assess retrospectively the effectiveness of the DPI in predicting the outcome and survival of root filled teeth previously recruited in the context of a prospective cohort study (Al-Nuaimi *et al.* 2017). The null hypothesis was that there was no difference in the percentage of successful outcomes between groups of teeth with different DPI scores.

Material and methods

Data collection

Ethical approval by the Health Research Authority, UK (IRAS: 233932) was gained to collect patient data from the clinical records of patients who had already been successfully recruited as part of a prospective cohort study, which investigated the outcome of re-treated posterior teeth with varying degrees of coronal tooth structure loss (Al-Nuaimi *et al.* 2017).

Each of these patients had at least one posterior root filled tooth in function, diagnosed clinically and radiographically with symptoms and/or signs of the endodontic post-treatment disease which required root canal retreatment. The clinical and radiographic assessment at baseline and at recall are described in detail in Al-Nuaimi *et al.* (2017); in brief, all teeth had clinical and radiographic (digital periapical radiograph [PR] and CBCT) records at baseline and at recall documented in their clinical notes, all data were collected using a standardised proforma. The examination included medical and dental history taking, pre-operative pain history evaluation, and hard and soft tissue assessment. Root canal retreatments and cuspal coverage restorations were carried out by 20 calibrated Endodontic postgraduate students using a standardised protocol under the supervision of Endodontic specialists. Standardised clinical and radiographic assessment was carried out, including parallel periapical radiographs and CBCT scans with the same exposure settings used for the pre-operative scans, 1-year post-treatment.

Two pre-calibrated experienced endodontists were asked to identify the presence of radiolucencies associated with the apical portion of the roots of each tooth.

Assessing the Dental Practicality Index

Two experienced calibrated endodontists assessed the clinical notes, patient's study models and radiographs, and graded all cases according to the DPI criteria (Dawood & Patel 2017). The two examiners were not involved in carrying out the root canal retreatments and were not

aware of the treatment outcome. The inter-examiner agreement was assessed by evaluating 50% of the cases 2 weeks after the original evaluation.

Each of the restorative aspects; endodontic status, periodontal health, structural integrity, as well as the context of treatment were assessed and scored. After scoring each category, the sum of scores was then used to determine the overall DPI score (Table 1). The DPI score for each case was correlated with the outcome of the root canal retreatment.

Statistical Analysis

Descriptive statistics were used to define the characteristics of the study variables. Cohen's kappa was used for intra-examiner reliability analysis. Fleiss's kappa coefficient was used to assess the intra-consensus panel agreement for radiographic assessments of periapical health (Al-Nuaimi *et al.* 2017). The outcome of root canal retreatment was dichotomised into 'favourable' and 'unfavourable' (Table 2). A Chi-square/Fisher's exact test was used to establish a relationship between categorical variables, the total score of DPI vs outcome. The significance level was set at a= 0.05.

Results

One hundred and thirty-seven teeth were included. The average age was 43 years; 84 patients were females (69%) and 37 males (31%). Table 3 shows the distribution of the scores of the re-treated teeth in the four categories of the DPI. Out of the 137 teeth, 28 were premolars and 109 molars. The frequency distribution of the type of re-treated teeth, according to the total DPI score, is presented in Table 4. The DPI scores and the corresponding unfavourable outcome percentages are shown in Table 5.

There was a significant correlation between the percentage of favourable outcome and the DPI score of below 3 (97.1%, P=0.009), below 4 (91%, P=0.001) and below 6 (86%, P=0.001) (Table 6). Twenty-eight out of the 34 teeth with a DPI score of below 3 were molars. Of those, only one molar had an unfavourable outcome. In molar teeth, the percentage of favourable outcome was 96% when the DPI score was below 3, and 74% with a DPI score of 3 and

above. When the DPI score was below 3 there was a 10-fold (Fisher's exact test, odds ratio [OR] = 10.03; 95% confidence interval [CI]: 1.302-77.194, P<0.05) greater chance of a favourable outcome compared to those with a DPI score of 3 and above. The intra-examiner agreement for the DPI score using Cohen kappa statistic was 0.59.

Discussion

The most significant finding of the present study was that DPI scores of 3 or above were associated with an unfavourable outcome percentage of 23%, whereas the percentage of unfavourable outcome was 3% for teeth with scores below 3. In addition, a very high favourable result (96.4%) for molar teeth with a DPI score below 3 was observed (Table 5). This is the only study which assesses the outcome of root canal retreatment in relation to a combined restorative index.

Thus, molar teeth with a reasonable amount of coronal tooth structure, simple root canal retreatment and no other complications such as, periodontal disease or complex root canal anatomy had a favourable outcome assessed using CBCT, which is actually higher than that observed in molars undergoing primary treatments in a similar study (Patel *et al*. 2012).

Chen *et al.* (2008) evaluated 857 root filled teeth and determined the reasons for tooth extraction after root canal treatment. Whereas endodontically related problems accounted for only 11% of the extractions, extensive decay or unrestorable teeth (46%), tooth fracture (32%), and periodontal disease (27%) proved to be far greater problems. The non-endodontic causes of failure in these studies may have been due to poor pre-treatment assessment of the tooth planned for endodontic treatment, for example, a molar tooth with minimal tooth structure and lack of adequate periodontal support would have a guarded prognosis, as would a compromised tooth in a patient with parafunctional habits.

The study appears to confirm that a systematic evaluation scoring of a tooth using the DPI results in a good prediction of the outcome of root canal retreatment. Fifty percent of the cases were assessed 2 weeks later in order to determine the intra-examiner reliability. The intra-examiner variation as a measure of the reliability of the data collection was measured and the

results of this study are considered to have a moderate agreement (0.41-0.60) error (Landis & Koch 1977). A level of consensus panel agreement of 0.59 was found for DPI scoring. This moderate level of agreement suggests that there is some degree of subjectivity when using the DPI.

The DPI provides an algorithm for assessing a tooth before deciding whether to refer, undertake restorative treatment, or remove a tooth. In the United Kingdom, approximately 18% of the total number of dento-legal claims between 1996 and 2001 were associated with root canal treatment (Dental Protection Riskwise 2003). This might suggest that some dentists are attempting complex root canal treatments beyond their competence. At present, there are no objective guidelines which consider the various restorative aspects of the tooth and also consider the patient holistically, such a guideline would be desirable for helping dentists working in primary dental care to determine when they should consider referral of teeth with endodontic problems to secondary or tertiary care. A DPI score may prove to be a useful guide for both the referrer and the referral centre; as a DPI level 2 score in any one of the categories indicates that advanced training and expertise is desirable; i.e. these cases may be referred for secondary or tertiary care (Dawood & Patel 2017).

One of the advantages of the DPI is that its use encourages the clinician to consider the patient holistically, assessing the tooth in its context, and directing the treatment plan towards the patient's unique needs.

The patient sample included only a small number of patients with individual or total DPI scores of 6 or over, as teeth in these categories would have been more obviously unrestorable when assessed by an experienced clinician; such cases would therefore not have been treated knowing that the probability of failure would be high.

The study is ongoing; the effectiveness of the DPI index score in predicting the 4-year survival of teeth undergoing endodontic re-treatment will be assessed. However, this was not the purpose of the present study, which was undertaken on a relatively small group of patients included in a previous prospective study which had been solely powered for the evaluation of the effect of loss of tooth structure on endodontic outcome.

The DPI is intended to assist in assessing the practicality of providing predictable restorative treatments for teeth in need of restoration. It is anticipated that with time the DPI will become available to a wider range of assessors such as undergraduate students, general practitioners, postgraduates, and specialists, in order to test and report upon their ability to use this index to predict the outcome of root canal treatments and the survival of root filled teeth or teeth with multi-component restorative problems.

Conclusion

This study highlighted a good outcome prediction for root canal retreatments when using the DPI. However, further research, including the prospective assessment of a wider range of cases undertaken by a larger group of standardized examiners is needed to further validate the DPI.

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Table 1 Dental Practicality Index (DPI) (Dawood & Patel 2017)

Table 1 The categories that the tooth should be assessed in; structural integrity, periodontal and endodontic treatment need as well as context are summarised in the grey shaded columns. Each row shows examples of different levels (0,1,2,6) of complexity for each category. An overall DPI score of >6 indicates that treatment may be impractical, this is reduced to 4 if the tooth to be treated is to be used as a bridge abutment

Weighting	Structure integrity	Periodontal treatment need	Endodontic treatment need	Context
0 No treatment required	Unrestored or existing well-adapted restoration	Probing <3.5 mm (BPE 0-2) previously successfully treated periodontal disease	Vital pulp previously successfully treated endodontic disease	Local: Isolated dental problems where adjacent teeth are healthy General: Replacing of a strategic tooth may be excessively complex History of IV bisphosphonates, head & neck radiotherapy
1 Simple treatment required	Simple (in)direct restoration	Probing 3.5-5.5 mm (BPE 3) root surface debridement indicated	Simple root canal system with endodontic disease (eg, radiographically easily identifiable root canal[s], easily retrievable root canal filling material)	Local: Prosthodontic treatment planned of neighbouring teeth which may influence treatment plan for tooth being assessed Tooth to be used as a bridge abutment General: Radiotherapy of head and neck region planned Immunocrompromised patient
2 Complex treatment required	Minimal residual sound tooth structure (eg subgingival margins, post-core restoration required etc)	Probing >5.5 mm (BPE 4) compromised support (eg short root, crown lengthening required, grade 2 mobility). Grade 2-3 furcation involvement	Complex root canal system with endodontic disease (eg, sclerosed root canal, acute curvatures. Complex re-root canal treatment (eg, fracture instrument removal, perforations) Difficulty in obtaining anaesthesia	Local: Prosthodontic treatment planned of multiple, including adjacent teeth General: High caries rate Poor oral hygiene Parafunctional habits, extensive tooth surface loss Active periodontal disease
6 Impractical to treat	Inadequate structure for ferrule	Untreatable periodontal disease	Untreatable root canal system	Local: Retention of the tooth being assessed would constrain and/or compromise an otherwise simple and predicable treatment plan (for example extensive bridge work) General: Potentially life threatening medical conditions which should be managed in tertiary care

Table 2. The outcome categories for root canal retreatment (Patel *et al*. 2012, Al-Nuaimi *et al.* 2017)

Score	Description	Outcome
1	New periapical radiolucency	Unfavourable outcome
2	Enlarged periapical radiolucency	Unfavourable outcome
3	Unchanged periapical radiolucency	Unfavourable outcome
4	Reduced periapical radiolucency	Favourable outcome
5	Resolved periapical radiolucency	Favourable outcome
6	Unchanged healthy periapical status (no radiolucency before and after treatment)	Favourable outcome

Table 3 Frequency distribution of teeth in each of the four categories of the DPI

Variables		Count	%
Total		137	100.0
Structural integrity	score 1	72	52.6
	score 2	65	47.4
Periodontal state	score 0	106	77.4
	score 1	14	10.2
	score 2	17	12.4
Endodontic state	score 1	83	60.6
	score 2	54	39.4
Context	score 0	113	82.5
	score 2	24	17.5

Table 4 Frequency distribution of the type of re-treated teeth according to the total DPI score

Total DPI score	**Total number of teeth treated**	
	Premolar	Molar
2	6	28
3	14	30
4	6	19
5	1	17
6	1	13
8	0	2
Total	28	109

Table 5 Frequency distribution of teeth and unfavourable outcome in relation to the total score of DPI

	Total		
DPI score	**Number of teeth**	**Number of unfavourable outcomes**	**Percentage of unfavourable outcome**
2	34	1	3%
3	44	6	14%
4	25	8	32%
5	18	2	11%
6	14	6	43%
8	2	2	100%

Table 6 Overall outcome of teeth according to the DPI scores

DPI score	Outcome			Favourable outcome %	P- value
	Favourable	Unfavourable	Total		
< 3	33	1	34	97%	0.009
³ 3	79	24	103	77%	
< 4	71	7	78	91%	0.001
³ 4	41	18	59	70%	
<5	88	15	103	85%	0.052
³ 5	24	10	34	71%	
< 6	104	17	121	86%	0.001
³ 6	8	8	16	50%	