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The relationship between endodontic case complexity and treatment outcomes

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ABSTRACT

Objective: The aim of this work is to correlate between endodontic case complexities and treatment quality outcomes.
Methods: Three hundred and forty nine radiographs of patients who had received endodontic treatment at a postgraduate dental institute in Dubai were retrieved from the Institute's data base. The majority of the cases were referred by in house general dental practitioners (GDPs). Unreadable radiographs were all excluded. From the original sample of 349,in total 51 radiographs were discarded. The final sample thus consisted of 298 root canal fillings of 211 patients treated by the endodontic postgraduate students. All radiographs were individually evaluated following the American Association of Endodontic Case Difficulty Assessment Form. Based on this, the technical quality of the root filling was evaluated for each individual case.
Results: The sample consisted of 53% high,35% moderate and 12% minimal difficulty cases. Adequate homogeneity of root canal fillings were found in 93% of the cases. This compared with 90% of cases with adequate length of root fillings. There were statistically significant differences between the length of root canal filling and level of difficulty ($p = 0.016$) but, no statistically significant difference between homogeneity of root canal filling and case difficulty ($p = 0.794$).
Conclusion: Eighty four percent ($0.93 \times 0.90 = 0.84$) of the cases treated proved to be adequate in terms of length and homogeneity which is in line with published work of Endodontic treatment carried out by specialists.
Clinical Significance: GDPs require robust guidelines to help with appropriate referral of patients to Endodontic specialists.

1. Introduction

The primary goal of endodontic therapy is to prevent or heal apical periodontitis. A thorough knowledge of both root and root canal morphology is a fundamental prerequisite to help ensure optimal outcomes of root canal treatment [1]. From a biomechanical perspective this means cleaning, shaping and disinfecting that would allow for three-dimensional obturation of the root canal system [2–4]. This includes careful preoperative assessment and intraoperative care to identify the landmarks of normal morphology as well as any unusual anatomy of the root and root canal system.

It is well known that the technical quality of root canal treatment affects the outcome of endodontic treatment in terms of periapical healing [5–9]. In a prospective study on factors affecting outcomes of non surgical root canal treatment eleven prognostic factors were identified [10]. Amongst these were achievement of patency and extension of cleaning as near as possible to the root canal terminus. These factors were statistically significant ($P < 0.05$) in terms of final success rate of endodontic treatment.

A good percentage of all Endodontic treatment is carried out by General Dental Practitioners (GDPs) and undergraduate dental students. A number of studies [11–13] suggest that root canal treatments carried out in these settings are not of adequate quality. In a study carried out in Belgium [13] 300 root filled teeth were evaluated of which over 50% were scored inadequate. Similarly, in a study carried out in Taiwan [14], 1085 root canal treatments were assessed in terms of length of root filling and homogeneity. Approximately 70% of the cases were found to be inadequate. Similar findings were reported in a Scottish [12] and a Swedish population [15].

Two studies [13,16] have used panoramic radiographs to assess the

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quality of the root fillings and apical pathosis. The main disadvantage of panoramic radiographs is that the image does not display the fine anatomic detail available on periapical radiographs. Thus it is not as useful as periapical radiographs in detecting periapical pathology. The resolution of panoramic systems is also limited by mechanical motion to approximately 5 Ip/mm [17].

The quality of root canal fillings performed by undergraduate dental students in Turkey [18] was assessed for technical quality. As with the Taiwan population [14] the technical quality was assessed according to length and homogeneity of the obturation. Although technical quality for obturation of anterior teeth was considered high (around 90%) less than 50% of posterior teeth were reported to have satisfactory quality of endodontic treatment. The technical quality of root canal fillings deemed acceptable performed by undergraduate dental students on single rooted teeth at a dental school in Cork, Ireland was reported as 63% [19]. Similary, Khabbaz et al [20] found that only 39% of the root fillings performed on an undergraduate clinic were satisfactory whereas, perhaps not surprisingly, the figure for anterior teeth rose to 71%. In contrast root canal fillings performed on a postgraduate program in Brazil [21] found that around 51% of the cases were perfect obturations and 41% were deemed satisfactory obturations. Similarly, a study assessing the quality of root canal fillings amongst Australian Endodontists showed that over 77% of root fillings were of a high technical quality [22]. Clearly, many of the higher difficulty Endodontic cases are better dealt with in a specialist setting.

In most of the reported studies [12–14] on technical quality treatment is based on homogeneity and length of the root canal treatment. Some studies [23,24] have also considered such factors as taper and the presence of iatrogenic errors including altered root canal morphology following endodontic treatment in addition to length and homogeneity as part of the assessment of the quality of the obturation.

There are a number of guidelines available such as The American Association of Endodontists (AAE) Case Difficulty Assessment Standards [25], The Canadian Academy of Endodontics (CAE) Complexity Index [26] and The Dutch Endodontic Treatment Index (DETI) [27] to assess case complexity. Muthukrishnan et al [28] found a lack of reproducibility in the Restorative Index of Treatment Needs (RIOTN) compared to the American, Canadian and Dutch guidelines which assign a cumulative numerical value to the Endodontic case. The final score reflects the complexity of the case; the higher the score the more complex the case. The importance of the guidelines is clear in helping the GDP to assess the complexity and refer accordingly. Endodontic specialists usually have advanced skills as well as latest equipment such as an operating microscope and 3D imaging equipment to manage complex cases.

The aim of this work was to correlate between endodontic case complexities and treatment quality outcomes carried out on a postgraduate endodontic teaching clinic. The null hypothesis that there is no difference between endodontic case difficulty and technical outcome was tested.

2. Materials and methods

This is a retrospective study to determine the relationship between endodontic case difficulty and treatment outcomes. A total of 349 radiographs of patients who had received endodontic treatment at a postgraduate dental institute in the UAE were examined. Unreadable radiographs due to technical errors, superimposed anatomical structures and incomplete treatments were all excluded. From the original sample, a total of 51 radiographs were discarded. The final sample thus consisted of 298 root canal fillings of 211 patients. All 298 radiographs were taken with a film holder and positioning device. All the patients were treated by endodontic postgraduate dental students under the supervision of Endodontic specialists.

The selected sample (n = 298) was divided into categories of minimal, moderate and high difficulty. For this purpose, two guidelines widely in use (the AAE Case Difficulty Assessment Standards [25] and the Restorative Index of Treatment Needs [28] were separately assessed using the Agree II tool [29]. Agree II assesses guidelines across 6 domains namely; scope and purpose, stakeholder involvement, rigor of development, clarity of presentation, applicability and editorial independence. There are 23 questions in total spread across the 6 domains. Each question carries a maximum score of 7. The maximum score achievable is, therefore, 161 (23 × 7). Of the two guidelines assessed, the AAE Case Difficulty Assessment Standards [25] scored the highest (82 compared with 51 for the RIOTN) accordingly, the AAE was selected for this work and all 298 cases were categorized based on this guideline. Additionally, thirty cases were randomly selected from the original sample of 298 and re-assessed this time using RIOTN.

All radiographs were individually evaluated in accordance with AAE Endodontic Case Difficulty Assessment Form. These included patient consideration, diagnostic and treatment consideration, trauma history, endodontic treatment history and Periodontal-Endodontic Condition. The relevant data obtained for the cases were appropriately categorized as minimal moderate and high difficulty. This process was repeated after 3 months. The purpose of the time separation between the two assessments was aimed to minimize any risk of the observer giving an opinion that was contaminated by the memory of the previous viewing. Inter/intra observer reliability were assessed via a Kappa analysis. Both intra and inter-observer kappa scores were calculated and found to be 0.90 in both cases. This high figure indicated a strong level of agreement [30].

The technical quality of the root fillings was assessed via two main parameters (i) homogeneity of the root filling and (ii) distance between the end of the filling and radiographic apex (Table 1).

Statistical Package for the Social Sciences (SPSS) version 20 was used for the study. Chi square tests were applied to the data ($p < 0.05$).

3. Results

The average age of patients in this study was found to be 41. The total sample number was 298 teeth (one tooth per patient) made up of 173 male and 125 female patients. Of the 298 teeth, 143 teeth were molars. The case mix of the sample presented was predominantly that of high difficulty (53%) followed by moderate difficulty (35%) leaving only 12% of minimal difficulty.

With regard to technical outcome, the overwhelming majority 84% were homogeneity acceptable and length acceptable. The relationship between case difficulty and technical outcome is exhibited in Fig. 1. This shows across all three levels of difficulty (high, moderate and low) that homogeneity and length acceptable was 91.7%, 89.5% and 79% respectively. This was statistically significant ($p < 0.05$) compared with all other technical outcomes. To assess the relationship between

Table 1
Criteria for technical quality of root filling.

Length of the root filling	Homogeneity of the root filling
Root filling terminating 0-2 mm from the radiographic apex (acceptable)	Homogeneous root filling, good condensation, no voids visible (acceptable)
Root filling terminating > 2 mm from the radiographic apex (unacceptable)	Inhomogeneous root filling, poor condensation, voids visible (unacceptable)
Root filling extending beyond the radiographic apex (unacceptable)	N/A

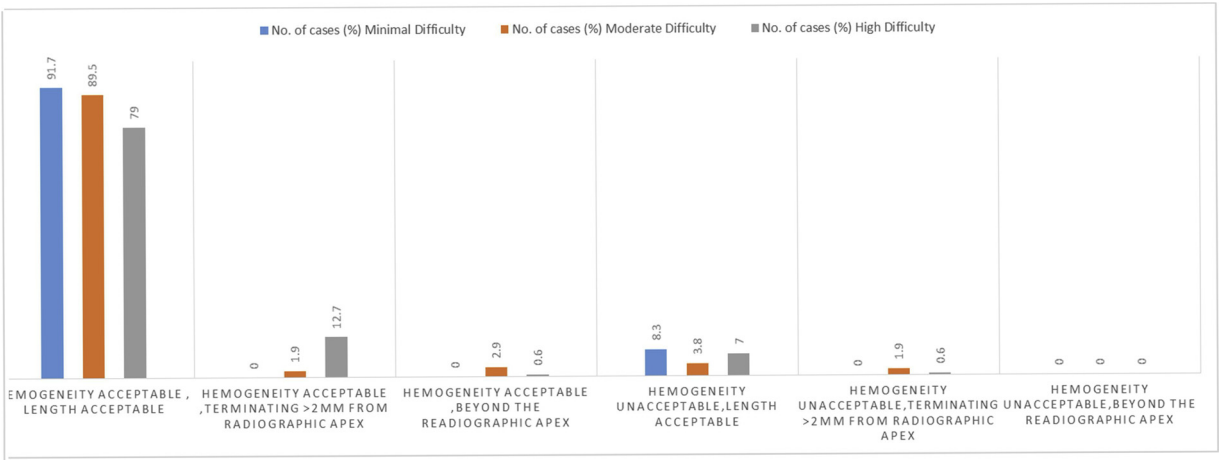

Fig. 1. Relation between case difficulty and technical outcome.

Table 2
Relation between case difficulty and length/homogeneity of obturation.

Case Difficulty	Adequate Length	Inadequate Length	p value X^2	Adequate Homogeneity	Inadequate Homogeneity	p value X^2
Minimal	36(13.4%)	0(0%)		33(11.9%)	3(14.3%)	
Moderate	98(36.4%)	7(24.1%)	0.016	99(35.7%)	6(28.6%)	0.794
High	135(50.2%)	22(75.9%)		145(52.3%)	12(57.1%)	

length and homogeneity on technical outcome, the individual results are displayed in Table 2. Of interest to note for all three case difficulties is the statistically significant difference in quality outcome and length of obduration (P = 0.016) but not for homogeneity (p = 0.794).

The quality of endodontic treatment outcomes is also related to tooth type, radiographic appearance and endodontic treatment history (Table 3). There appeared to be significant statistical differences between a number of these variables and endodontic outcomes ($p < 0.05$).

The result of categorising the thirty randomly chosen cases out of the original sample of 298 with RIOTN are tabulated (Table 4). The corresponding outcomes using the AAE of Endodontists Case Difficulty Assessment form are also added to the same table for direct comparison purposes. The results show that both guidelines agree fully on 20 (two thirds of the sub sample). Surprisingly, two out of the remaining 10 were classified as high difficulty with AAE but complexity 1 (low in AAE classification) with RIOTN. The remaining 8 were only out by "one complexity".

Table 3
Relation between case difficulty and tooth type/radiographic appearance/endodontic treatment history.

Criteria for case difficulty	Good quality obturation	Improper quality obturation	p-value (X^2)
Tooth type			
Anterior/premolar	89.7%	10.3%	
1st molar	72.2%	27.8%	0.003
2nd molar	82.3%	17.7%	
Radiographic appearance			
Visible canal	86.6%	13.4%	
Reduced size of canal	76.4%	23.6%	0.006
Canal(s) not visible	54.5%	45.5%	
Endodontic treatment history			
No previous treatment	87.9%	12.1%	
Previous access without complication	78.1%	21.9%	0.050
Previous access with complication	76.9%	23.1%	

Table 4
Classification of case difficulty/complexity according to AAE and RIOTN.

Case No.	Tooth	AAE	RIOTN
1	12	Low	1
2	21	Low	1
3	25	Low	1
4	22	Low	1
5	24	Low	1
6	14	Low	1
7	11	Low	1
8	13	Low	1
9	14	Low	1
10	35	Low	1
11	24	Moderate	2
12	45	Moderate	2
13	16	Moderate	2
14	21	Moderate	1
15	11	Moderate	1
16	26	Moderate	1
17	25	Moderate	1
18	45	Moderate	1
19	46	Moderate	3
20	45	High	2
21	45	High	3
22	15	High	1
23	45	High	3
24	24	High	2
25	22	High	3
26	21	High	3
27	45	High	3
28	36	High	3
29	11	High	3
30	37	High	1

4. Discussion

Endodontic cases normally present in one of three categories; minimal, moderate or high difficulty. The AAE guidelines for endodontic case difficulty were applied to categorize the patient sample used in this study. Complex Endodontic cases are normally referred by GDPs to various specialist services. The need for clear referral

guidelines are, therefore, obvious.

In this study, the average age of the patients was 41 years and there was no particular gender bias in the sample. It is well known that endodontic treatment becomes progressively harder with increasing patient age due to many factors such as physiologic aging, pathology and reduction in the size of the pulp canal space arising from the production of secondary and tertiary dentine and cementum [1]. By the time patients reach their forties, the chances are that they are undergoing restorative maintenance including failure of restorations and endodontic retreatment not to mention the likelihood of associated complex medical histories [31,32]. This trend was also confirmed in a cross sectional study looking at factors associated with failure of Endodontic treatment. The highest failure in their sample was seen in the 41 to 50 year age group (23.7%) [33]. A failure of 12.2% in the 50 year old age group and younger was reported by Ricucci et al. [34] Therefore, with average patient age of 41 years, in this sample, it is clear that the cases were relatively challenging. It is also interesting to note that only 18% of the sample were anterior teeth. That said, a number of these were trauma cases (around 2%) which have associated problems such as resorption and obliterated canals which automatically fall into the high difficulty case mix [35,36].

The technical outcome in this study revealed that 84% were acceptable on both counts of homogeneity and root filling length. At the other extreme where both homogeneity and length are unacceptable, the corresponding figure was only 1%. The results were statistically significant at $p < 0.05$ (Fig. 1). Further in Table 2 the data for length of obturation and homogeneity were separated and assessed individually. Quality of obturation was statistically significant across all the case difficulties but only in terms of length ($p = 0.016$) and not homogeneity ($p = 0.794$). The percentage of inadequate length steadily increased with increasing case difficulty which is to be expected. This is also in line with the results reported in another study for the high difficulty cases [23]. The reason for this could be attributed to the fact that retreatment cases often present with previous endodontic mishaps such as blockages and ledges [9] which prevent instrumentation to full working length. There may also be damage to the apical constriction from previous shaping procedures, again contributing to an incorrect, usually in this situation, overextended obturation. In a study of outcome of endodontic retreatment at 2-year follow up, the overall success rate was reported to be 69.03% but, this reduced significantly to 47% if the root canal morphology was previously altered [23].

The classification of case difficulty can sometimes change depending on the particular guidelines used which are not always based on the same criteria. With this in mind and to illustrate the matter further, a random sample of 30 of the cases were selected and classified using the RIOTN system. A number of striking anomalies were seen. Two cases classified as high difficulty according to the AAE of Endodontic Case Difficulty Assessment Form were classified as complexity 1 according to the RIOTN. Investigating these cases further, the differences occurred due to a history of complex signs and symptoms in one of the cases, and in the other case due to the position of the tooth, the presence of a multi surface restoration and the nature of the endodontic history. Following on from the above, one would assume that such cases may only be referred depending on which guideline is used. The percentage of satisfactory versus unsatisfactory treatments was highest for anterior/premolar teeth followed by second molars. The differences were statistically significant ($p = 0.03$). That said, even in cases of first molars, the percentage of satisfactory treatment were still above 70%. With regard to radiographic assessment of the pulp space on the preoperative radiograph, understandably where canals were not visible would result in a substantial reduction in satisfactory success rate (87% when canals are visible versus 55% when canals are not visible). Again this was statistically significant ($p = 0.006$). In contrast to the above trends, there were not much differences in success rate ($p = 0.05$) between primary treatment and cases which had been accessed previously (88% versus 77% satisfactory outcome).

5. Conclusions

The cases examined in this study were predominantly high followed by moderate difficulty cases. The results show that complex cases need to be referred to specialist centres such as the one in this study. Robust guidelines are required to assist GDPs in making appropriate referrals.

Declaration of interests

None.

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