Moisture Analysis of Endodontically Treated and Sound Teeth Using Moisture Analyser and Indirect Gravimetric Analysis

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ABSTRACT

BACKGROUND

Endodontically treated teeth are supposedly more prone to fracture. Dehydration of dentinal tubules was considered as one of the main reasons leading to increased weakness of endodontically treated teeth. The effect of root canal treatment on structural changes of the remaining tooth structure leading to brittleness is a long debated topic. There is a dearth of conclusive evidence on the factors responsible for fracture of endodontically treated tooth. Literature has suggested the brittleness to be more related to destruction of tooth structure / tooth structure loss than actual loss of moisture. The role of moisture influencing the biomechanical behaviour of teeth has neither been well understood nor fully investigated. Thus the aim of this study is to determine the difference in moisture content between endodontically treated teeth and sound teeth which might have a bearing on the brittleness of teeth.

METHODS

Twenty freshly extracted endodontically treated teeth and twenty sound teeth were divided into two equal groups namely A and B. Moisture content determination was done using two methods, namely, a non-destructive and rapid method using moisture analyser and by using indirect gravimetric analysis. The values were recorded in each case. The data tabulated were subjected to unpaired t test.

RESULTS

The mean moisture content determined using moisture analyser in Group A and Group B were 3.9 ± 0.93 and 4.14 ± 0.55 respectively ($p > 0.05$). Using indirect gravimetric analysis, in Group A, it was found to be 4.52 ± 0.38 and in Group B it was found to be 4.45 ± 0.55 ($p > 0.05$). No statistically significant differences were present between both the groups. Both moisture analyser and indirect gravimetric analysis showed similar results in determining the difference in moisture content between endodontically treated teeth and sound teeth.

CONCLUSIONS

Within the limitations of this study, it may be concluded that the lack of statistical difference using two established methods for free moisture analysis between teeth that have undergone endodontic treatment 2 - 3 years ago and sound teeth refutes the concept of endodontically treated teeth becoming brittle over time and hence should not affect the clinical outcome. Nevertheless, more studies are required to substantiate the same.

KEY WORDS

Endodontically Treated Teeth, Sound Teeth, Moisture Analyser and Indirect Gravimetric Analysis

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BACKGROUND

It is a widely held clinical perception that endodontic treatment renders teeth weaker and more prone to fracture than normal vital teeth.[1-4] Mechanical terminologies have been frequently used by many authors to describe the physical condition of teeth that have undergone root canal treatment, such as increased "brittleness", "friability", and "fragility"; reduced "resiliency", "elasticity", and "strength".[4-6] The reduction in tooth structure and the effect of dehydration on the dentinal tubules are widely considered to be the main reasons associated with increased weakness and brittleness of endodontically treated teeth. [4] The dentinal collagen shows more structural differences like more incomplete bindings are seen in the collagen of non-vital teeth when compared to the vital teeth causing weakening of the collagen network.[7] The dentinal fluid flow in a vital tooth is under a slight positive pressure of 15 cm H_2O (147 KPa).[8-10] This pressure is due to the blood flow through the pulpal tissues.[11] The dentin of a non-vital tooth becomes brittle when this fluid flow is altered by blood supply removal.

In 1895, Black concluded that the dentin of an endodontically treated teeth had less crushing strength than normal teeth.[12] Carter et al. in 1983 also showed the reduction of shear strength and shear toughness of endodontically treated teeth.[13] A study by Reeh et al revealed that endodontic procedures reduce the tooth stiffness by only 5 %.[14] In a recent study by Zelic K et al, wherein access cavity preparation and root canal treatment was performed in teeth with mesio-occusal cavity, it was seen that removal of tooth structure, despite its restoration with dental materials, weakened the tooth by changing the stress intensity and distribution through tooth structures. It was also found that access cavity preparation had the greatest influence on tooth strength whereas biomechanical preparation of the canal did not contribute to this process substantially.[15]

The role that moisture plays in the biomechanical behaviour of teeth has not been well understood nor fully investigated. The purpose of this study was to determine the difference in moisture content between endodontically treated teeth and sound teeth so that clinicians and academicians might be able to comment conclusively on the effect of endodontic treatment on tooth moisture.

The research hypothesis of this study is that there will be no difference in moisture content between endodontically treated teeth and sound teeth when evaluated using moisture analyser and indirect gravimetric analysis.

METHODS

This was a prospective study conducted in the Department of Conservative Dentistry and Endodontics. Institutional Ethics Committee clearance (GNIDSR / IEC / 19 - 23) was obtained for this experiment.

Inclusion Criteria

For Endodontically Treated Teeth

- Freshly extracted molars that have undergone root canal treatment 2 - 3 years ago, irrespective of presence or absence of crown.
- Extractions performed on patients of age group 20 - 45 years.
- Teeth weighing at least 2.5 gm (digital weighing machine).
- Well-obturated root canals, which was assessed by two experienced endodontists who were blinded to the treatment groups. Inter examiner reliability was analysed with Cohen kappa analysis.
- Reasons for extraction were loss of periodontal support, clinically symptomatic after endodontic treatment requiring extraction and persistent periapical lesion cases not amenable for retreatment and patient is unwilling for the same.

For Sound Teeth

- Intact vital molars (sound teeth, where the surface is sound, there is no clinically detectable lesion, the dental tissue appears normal in colour, translucency and glossiness).[16]
- The pulpal status was checked using cold test (Endo ice).
- Extractions performed on patients of age group 20 - 45 years.
- Teeth weighing at least 2.5 gm (digital weighing machine).
- Third molars requiring extraction.
- Molars extracted due to loss of periodontal support.

Exclusion Criteria

- Grossly carious teeth with more than 50 % decay.
- Vertical root fracture.
- Teeth extracted from medically compromised patients.
- Teeth that are not under the purview of inclusion criteria.

The extractions were performed in the oral and Maxillofacial Surgery Department in the institute. Freshly extracted human molar teeth fulfilling the inclusion and exclusion criteria were collected and divided into two groups, Group A-endodontically treated teeth and Group B: sound teeth. Based on the results of pilot study and in order to obtain confidence interval level of 0.95, at least 80 % power, Open Epi software version 3.01 was used for sample size determination. Twenty samples in each group was collected (n = 20).

Sample Preparation

Visible blood and gross debris on the collected samples was removed using hand scaler as per Centers for Disease Control and Prevention.[17] The collected teeth were kept in HBSS (Hank's Balanced Salt Solution) were subjected immediately for moisture analysis.

Moisture Content Determination Using Moisture Analyser

Moisture content of each sample of both the groups was determined using moisture analyser[18] (HE53Mettler Toledo). The readings were recorded.

Moisture Content Determination Using Indirect Gravimetric Analysis

After the moisture content determination using moisture analyser, the samples were subjected to indirect gravimetric analysis.[19] The cervical portion of each tooth sample were sectioned using diamond disc at a slow speed under influence of a coolant. The specimens were weighed in a digital balance and the pre-heat weight was recorded. Following which, the specimens were placed in hot air oven at 110° C for 8 hours, and the post-heat weight was recorded from the digital balance. The difference between pre-heat weight and post-heat weight was calculated which determined the free water content.

Statistical Analysis

Data was analysed using Statistical Package for Social Sciences (SPSS) version 21. Normality of the data was checked by Shapiro Wilk test. Data was found to be normal. Keeping in view the nature (continuous) & distribution (normal) of data, inferential statistics were performed using parametric tests of significance. Student's unpaired t test was done to compare the moisture content between endodontically treated teeth and sound teeth using moisture analyser and indirect gravimetric analysis. The level of statistical significance was set at 0.05.

RESULTS

The mean moisture content for the teeth samples in Group A and Group B using moisture analyser and indirect gravimetric analysis are presented in Table 1. The mean moisture content determined using moisture analyser in endodontically treated teeth and sound teeth were 3.9 ± 0.93 and 4.14 ± 0.55 respectively, t = - 0.62759, p = 0.269078 (p > 0.05). Using indirect gravimetric analysis, in endodontically treated teeth, it was found to be 4.52 ± 0.38 and in sound teeth it was found to be 4.45 ± 0.55, t = 0.23548, p = 0.408247 (p > 0.05). No statistically significant differences were present between both the groups. Both moisture analyser and indirect gravimetric analysis showed similar results in determining the difference in moisture content between endodontically treated teeth and sound teeth. Cohen kappa analysis for interrater agreement determined a kappa value of 0.619 (percentage of agreement = 91.666 %, showing substantial agreement).

Groups	Moisture Analyser			Indirect Gravimetric Analysis			P Value
	Mean	S.D.	t	Mean	S.D.	t	
A (n = 20)	3.9	0.93	- 0.62759	4.52	0.38	0.23548	0.269078 (p > 0.05)
B (n = 20)	4.14	0.55		4.45	0.55		0.408247 (p > 0.05)
Total N = 40							

Table 1. Comparison of Moisture Content Analysis Endodontically Treated Teeth and Sound Teeth Using Moisture Analyser and Indirect Gravimetric Analysis

DISCUSSION

The word "brittle" means hard but liable to break easily, "friability" describes the tendency of a solid substance to break into smaller pieces under duress or contact, "fragility" is the quality of being easily broken or damaged, all of which describes the physical condition of the dentin of endodontically treated teeth. A material is said to be "resilient" when the amount of energy absorbed within a unit volume of that structure is stressed to its proportional limit, "strength" is the maximum amount of stress that a material or a structure can withstand without sustaining a specific amount of plastic strain or stress at the point of fracture, "elasticity" is the ability of a material to resume its normal shape after being stretched or compressed.[20] The dentin of an endodontically treated tooth is supposedly known to exhibit reduced resiliency, strength, elasticity. The clinical concept of "brittle"[21] or weakened endodontically treated teeth has been attributed to the loss of tooth structure due to trauma, caries, endodontic access, instrumentation and irrigation procedures, and / or to changes in properties of teeth following endodontic treatment. Endodontic treatment causes structural changes like the incomplete binding of collagen bundles due to dehydration, certain physicochemical alterations caused by endodontic chemical products like sodium hypochlorite, chelators and, calcium hydroxide during chemo-mechanical debridement. In a study by Helfer et al, it was found that the dentin of pulp less teeth had 9 % lower moisture content than the dentin of contralateral vital teeth, with the difference attributable to loss of free water.[5] The free water, lost by moderate heating at 105 - 110° C (indirect gravimetric analysis) was measured in this study since this was the only component reported earlier to be affected by the loss of pulp vitality.[19] Thereby, moisture content analysis of an endodontically treated tooth is a relevant clinical issue.

In the present study, the mean moisture content in endodontically treated teeth and sound teeth was statistically insignificant (p > 0.05), when evaluated using moisture analyser and indirect gravimetric analysis. Thus the null hypothesis is accepted. The findings corroborated with a study done by Papa et al.[21] who reported that vital dentin had a moisture content of 12.4 % whereas dentin from endodontically treated teeth had a moisture content of 12.1 %. Other studies by Sedgley et al[22] also showed that endodontically treated teeth do not become more brittle intrinsically following treatment. All these findings suggested that other factors may be more critical leading to the increased brittleness of endodontically treated teeth.[18] Traditional endodontic access cavity involves removal of a considerable amount of dentin, coronally to gain straight-line access to canals, and in the radicular area by over flaring of canals orifices, which may weaken the tooth and increases its susceptibility to fracture and eventual extraction.[23] Loss of coronal tooth structure to gain straight-line access has a significant decrease in fracture resistance compared to root canal and post preparation.[24] The concept of minimally invasive dentistry and the newly emerging imaging devices, illumination and magnification have inspired the emergence of the recent conservative endodontic access cavity. A study by Osman et al[18] showed that the fracture strength of a

conservative access cavity was statistically significantly higher compared to a traditional access cavity. Tooth preparation for full coverage cast restoration also leads to the weakening of endodontically treated teeth.

It is seen that a higher concentration of sodium hypochlorite (around 5.25 %) which is used at times in endodontic therapy caused the softening of dentin if the action time exceeds 10 minutes.[7] It also has proteolytic action, owing to which, there is extensive fragmentation of long peptide chains, including collagen which leads to a reduced modulus of elasticity and flexural strength of dentin.[7] In a study by Habelitz et al. it was seen that storage of samples for testing in calcium chloride solution or distilled water, significantly lowered their elastic modulus and the hardness because it altered the calcification. Storage of tested samples in Hank's balanced salt solution for a period of two weeks did not show any changes in the outcome, whereas storage in the other mediums for the same period lowered the mechanical properties up to 50 %.[25] In the present study, precautions were undertaken to avoid both the loss of moisture by keeping the samples in Hank's balanced salt solution in sealed containers and subjecting immediately for moisture analysis.

The structural strength of the tooth in terms of dentin moisture is critical since the dentin serves as a substrate for most endodontic as well as restorative procedures. Substantial dehydration changes the fracture characteristics of dentin specimens. (Huang et al, 1992).[5] A range of biomechanical features such as the collagen crosslink content of dentin is affected by moisture. (Sedgley et al, 1992)[22] Biomechanical preparation of the root canal system reduces the tooth strength, which is proportional to the amount of tissue removed, also it might be related to the chemical or structural alteration caused by various endodontic chemical products.[7] Studies have revealed that maximum tooth fragility in an endodontically treated tooth resulted from an endodontic access cavity combined with a MOD (Mesio-Occlusal-Distal) preparation.[7]

However, presently there is no objective definitive proof of any relationship between the mechanical weakening of dentin and moisture content. The in vitro techniques used in this study could help in studying these questions. Further, studying the impact of dentin moisture content on structural strength of teeth, in vitro, requires access to a simple but non-destructive method to objectively measure dentin moisture conditions, which was achieved by the use of moisture analyser. Although indirect gravimetric analysis gave similar results as the moisture analyser, the time taken by this method was comparatively longer.

CONCLUSIONS

Within the limitations of this study, it may be concluded that:

- No statistically significant difference has been observed in the moisture content between endodontically treated teeth and sound teeth.
- Moisture analyser and indirect gravimetric analysis methods have been used to determine the moisture content between endodontically treated teeth and sound teeth. The moisture content assessment using these methods has not shown any statistically significant differences.
- Determination of moisture content using moisture analyser required less time compared to indirect gravimetric analysis.

Thus according to this study, the lack of statistical difference using two established methods for free moisture analysis between teeth that have undergone endodontic treatment 2 - 3 years ago and sound teeth refutes the concept of endodontically treated teeth becoming brittle over time and hence should not affect the clinical outcome. Considering the sample size, and variation in the remaining tooth structure of teeth requiring endodontic treatment, further studies involving more variations in size of sample, time elapsed since the endodontic treatment has been performed and remaining tooth structure are required to arrive at higher levels of evidence based conclusions.

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