Original Article

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Butterfly Effect: Does it Correlate with Age and Gender?

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Abstract

Background: Dentinal translucency is one of the significant parameters used for dental age estimation that is least affected by pathologic processes and environmental changes. Butterfly effect is an optical phenomenon seen in some cross-sections of tooth roots due to root dentine translucency. *Aim:* To determine if the butterfly effect in the cross sections of teeth correlates with the age and gender of the individual. *Material and Methodology:* 90 extracted teeth specimen with known age & gender were collected from 3 age groups with equal gender distribution [30 each group- Group-I (15-24 years), Group-II (25-44 years) and Group III (45 years and older)]. Thecross sections of roots were cut at apical, middle and cervical one third and examined for presence of butterfly effect under light and polarized microscopy. *Statistical Analysis:* Pearson's chi square test was applied to calculate the data between all the three groups. *Results:* Occurrence ofbutterfly effect increased from Group-I to Group III with a mean percentage of 5.6%, 28.9% & 54.5% respectively. The effect was mainly featured at apical third in Group –I, while it could be observed at all the levels in Group III. The chi square test revealed a significant correlation between butterfly effect and age with a statistically significant p–value of 0.049 (less than < 0.5). *Conclusion:* The presence of butterfly effect has strong correlation with age; however, it does not correlate with gender.

Keywords: Butterfly Effect; Dental Age Estimation; Dentinal Translucency.

Introduction

Certain cross sections of the tooth root exhibit butterfly effect when they are observed under polarized microscopy because of dentinal translucency seen at various levels of the tooth root [Figure 1]. The "butterfly" effect was first captured by Beust in 1931 as an optical marvel in some cross-sections of tooth roots [11].

Transparent or sclerotic dentin which is mainly seen in the apical region of the tooth root extends gradually towards the crown of the tooth [2]. The effect is seen in sections cut mesiodistally rather than buccolingually [Figure 2]. Tomeswas the first investigator to describe translucent dentin. He and

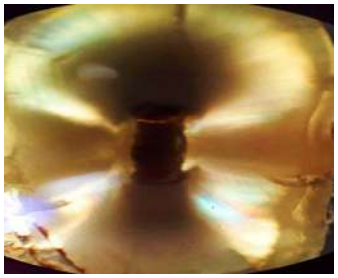

Fig. 1: Butterfly effect seen under polarized microscopy

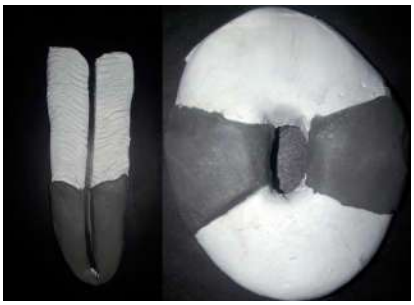

Fig. 2: Root dentine translucency begins from apex and extends coronally which is simulated using a clay model. A. longitudinal B. cross section

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Czermak held the opinion that various types of translucency arose because of an equalization of the normally different indices of refraction of the tubules and of the calcified dentin matrix [2]. The alteration is believed to be due to the decreased diameter of dentinal tubules caused by increased intratubular calcification. Hence, the difference in refractive indices between intratubular organic and extratubular inorganic material is equalized, resulting in increased translucency of the affected dentin [3]. Among all the parameters used in the estimation of age, dentinal translucency is the sole significant parameter for dental age estimation as dentin translucency is considered to be less inclined to deviate in pathologic processes and resists environmental changes [4].

It is generally accepted that the translucency of root dentin increases in the linear manner with age beginning from the apical end of the root [5,6]. The butterfly effect was initially observed for endodontic reasons to measure the density of the dentinal tubules by the presence of sclerotic dentin and obliterated tubules which negatively affect the formation of resin tags required for the adhesion of composite restorative materials. Restorations placed on sclerotic dentin with few dentinal tubules did not perform as well as those placed on dentin with patent tubules [1].

Literature on the butterfly effect is limited. Thus, it would be interesting to observe if the effect is present in the cross sections of teeth and if it has any correlation with age and gender of an individual.

Material and Methodology

The study was carried out in our Department of Oral and Maxillofacial Pathology at our institute. Ethical clearance for the present study from the institution was obtained. 90 extracted teeth specimens with known age & gender were collected ranging from Group I: 15–24 years old, Group II: 25–44 years and Group III: 45 years and over with equal gender distribution(30 each group). Subsequent to acquiring the consent from the patients, single rooted teeth were collected from the Department of Oral & Maxillofacial Surgery. The patients who were undergoing extraction of single rooted teeth because of various reasons like periodontal or orthodontic were randomly selected in the study. Fractured teeth, endodontically treated teeth, teeth with presence of root caries and cervical caries were excluded. The collected teeth specimens were cleaned and disinfected with 10% formalin. The teeth were kept in separate containers with labels of age and gender. Then dentinal translucency was observed on gross specimens.

Later, the teeth were decoronated and the cross sections of roots of 3 mm thickness were cut with the help of diamond disc at 3 different levels which were apical one third, middle one third and cervical one third [Figure 3]. As each tooth had 3 sections with a total of 30 teeth in each group, 90 sections were examined for presence of butterfly effect under light and polarized microscopy in each group amounting to a total of 270 sections studied.

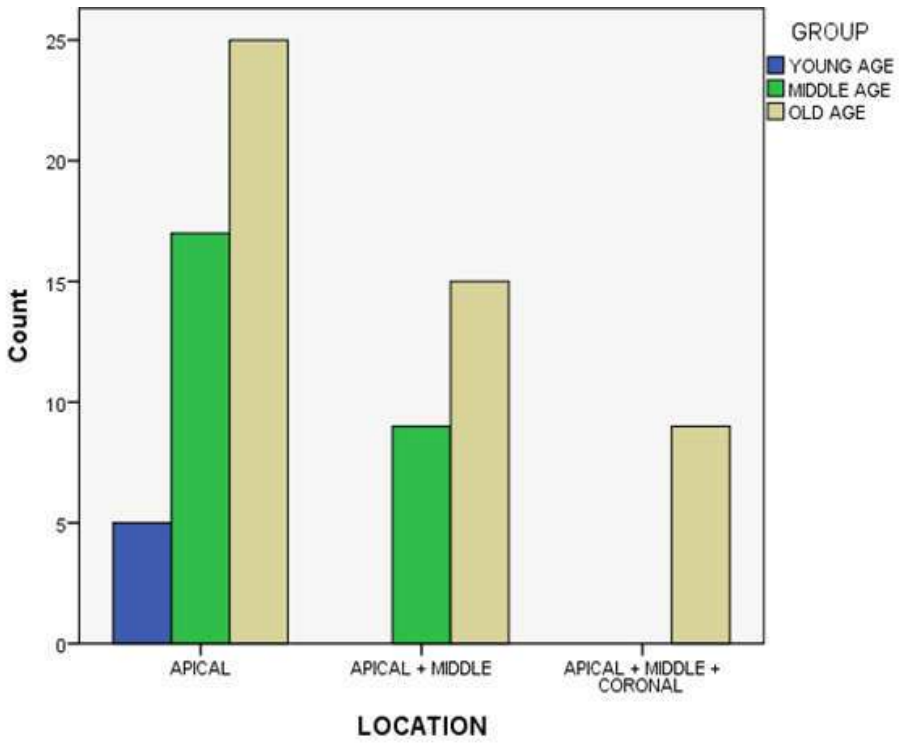
Results

Among all the sections studied, the butterfly effect was present in the mesiodistaldirection rather than buccolingual. The occurrence of butterfly effect varied significantly between the 3 age groups as calculated with Pearson's chi square test using SPSS20 software [Table 1]. Occurrence ofbutterfly effect increased from Group-I to Group III with a mean percentage of 5.6%, 28.9% & 54.5% respectively.

Table 1: Butterfly Effect Seen in Three Groups and the Levels at Which It Was Observed

			Group and location wise cross tabulation			
			Group			Total
			I Young (15- 24 Years) 90 Sections	II Middle (25-44 Years) 90 Sections	III OLD (>45 Years) 90 Sections	
Location	Apical	Count	5	17	25	47
		% within group	100.0%	65.4%	51.0%	58.8%
	Apical + Middle	Count	0	9	15	24
		% within group	0.0%	34.6%	30.6%	30.0%
	Apical + Middle + Coronal	Count	0	0	9	9
		% within group	0.0%	0.0%	18.4%	11.2%
	Total	Count	5	26	49	80
		% within group	100.0%	100.0%	100.0%	100.0%

Chi Square Value of 9.526
P -Value of 0.049
Strength of Association : Phi of 0.345 (Moderate Association)



Graph 1: Butterfly effect observed at all the three levels

Fig. 3: Cross sections of a tooth root sample from Group III exhibiting butterfly effect at all three levels

The level at which the effect was observed also varied between the 3 groups. The effect was mainly featured at apical third in Group –I, while it could be observed at all the levels in Group III [Graph 1]. The chi square test revealed a significant correlation between butterfly effect and age with a statistically significant P–value of 0.049 (less than < 0.5).

Discussion

The current study investigated the occurrence of butterfly effect in the cross sections of teeth to determine if the effect was featured throughout the root length and whether it was influenced by age and gender.

In 1950, Gosta Gustafson for the first time developed a method for age estimation based on histological changes of the teeth which was based on the measurement of regressive changes in teeth such as the amount of occlusal attrition, the amount of coronal secondary dentin formation, the loss of periodontal attachment, the apposition of cementum at the root apex, the amount of apical resorption and transparency of the root [5]. Gustafson's method has been critically tested and reviewed by several workers over the years. The two criteria, attrition and periodontal attachment were omitted in many of the subsequent modifications [7].

Dalitz in 1962 re-examined Gustafson's method and proposed that root resorption and secondary cementum formation could be disregarded. They opined that other criteria, attrition (A), periodontitis (P), secondary dentine (S) deposition, and transparency of the root (T) of the12 anterior teeth, were related appreciably to age and to a similar degree [7].

Furthermore, Johanson made use of all six age changes that Gustafson originally used. Then it was used to estimate or determine the ages of unknown bodies or individuals [6]. Kashyap and Koteshwar in 1990 evaluated only four of the age-related changes and did not use the root resorption and periodontosis criteria [8].

Maples in 1978 suggested the use of only two criteria of the total six criteria given by Gustafson which are secondary dentin formation and root transparency, in order to make the method more simple and accurate [9].

Bang and Ramm in 1970 were the first to use dentin translucency as a sole indicator for estimating age and reported significant increase in root translucency with age [2].

Miles stated that among the parameters used for assessing age for forensic purposes, translucency of the root apex seems to be the most reliable or the one with the closest straight-line relationship with age. He suggested that there is a gradual extension of the processes responsible for this translucency further and further in the direction of the crown as age advances, until, in due course, the whole of the root may be affected. The same opinion was held by Johnson [4].

Singh et al (2013) conducted a study in which longitudinal tooth sections were prepared in which they measured dentinal translucency with conventional and digital methods, and concluded that both the methods were very similar, with no clear superiority of one method over the other [10].

Kattappagari et al (2014) executed a study by doing ground sections of single rooted permanent anterior teeth and stained with 1% methylene blue. The area and length of dentin translucency were measured using digital Vernier caliper and with the help of stereomicroscope. They concluded that the area of translucency linearly increases as age advances [11].

In 2014, Ashith Acharya proposed a new digital method for measuring root translucency using commercially available computer hardware and software. Area and length were measured on 100 tooth sections (age range, 19–82 years) of 250 μm thickness. Regression analysis revealed lower standard error of estimate and higher correlation with age for length than for area (R = 0.62 vs. 0.60). From this study, he suggested that digital area measurements of root translucency may be used as an alternative to length in forensic ageestimation [12].

Russell et al. in 2013, discussed butterfly effect in their study investigating the density of dentinal tubules in mesiodistal and buccolingual cross-sections of tooth roots to determine effectiveness of the restorative materials placed on sclerotic dentin. They included thirty extracted single-rooted teeth of the groups according to the patient age: Group I: 15–24 years, Group II: 25–44years, and Group III: 45 years and over. The teeth were decoronated, and their roots were embedded in acrylic and cut into ten 1 mm-thick cross-sections.

Sections were viewed under a light microscope and presence or absence of the butterfly effect was observed. Two adjacent, consecutive cross-sections were chosen, and most coronal portions of root were cut mesiodistally and the other buccolingually. Scanning electron micrographs were taken of the central portion of their canal lumina and the density of the dentinal tubules determined [1].

In their study, the tubule density was found to be highest in the buccolingual root sections and lowest mesiodistally, a significant finding among all the age groups. From the study, they concluded that root sections with the butterfly effect have a lower density of dentinal tubules mesiodistally corresponding to the wings of the butterfly [1]. This finding is in concurrence to the observation made in the present study where, the effect was present in mesiodistal direction than buccolingual in all the root sections exhibiting butterfly effect.

Although their samples were chosen from different age groups, the main aim of the Russell's study was to check for the effectiveness of the restorative materials on sclerotic dentin by measuring the density of the dentinal tubules. They concluded that the presence of sclerotic dentin on proximal surfaces of the roots had obliterated tubules which negatively affected the formation of resin tags required for the adhesion of composite restorative materials [1].

Russell et al found that the butterfly effect was found at all levels in the roots of the teeth. In contrary to their study, butterfly effect was not featured in at all the levels throughout the length of the roots in our study. Occurrence of butterfly effect at different levels of roots varied among the different age groups. In Group I, the effect was present at apical level, in Group II it was present in apical and middle levels and Group III, the effect was present in apical, middle and coronal all the three levels [11].

Furthermore, in the present study, greater number of butterfly effect was observed in older age group individuals (Group III 54.5%) and middle age group individuals (Group II-28.9%) rather than young aged individuals (Group I 5.6%) individuals. It was also observed that the effect was featured in apical, middle and coronal thirds of roots of older individuals (Group III) and only in apical third of the root in younger individuals (Group I).

The correlation between the presence of the butterfly effect and gender of an individual was not a significant finding in our study. It is quite understandable as root translucency increases as the age advances, thus the butterfly effect is age related.

Dentinal translucency was observed on the gross specimen and then the effect was examined on the cross sections. Dentin translucency arises from apical region and gradually reaches towards coronal portion of the tooth. In the cross section of tooth, butterfly effect was observed when greyish translucent dentin was present with the normal opaque dentin. The effect could not be seen when whole cross section was showing translucent dentin with no opaque dentin present despite advanced age. This observation was made mainly in Group III teeth, where the butterfly effect was present in middle and coronal sections of root rather than at apical sections [Figure 4].

Fig. 4: Cross section of tooth root at apical level not exhibiting butterfly effect despite advanced age because of greater amount of transparent dentin with little normal dentin

The present study showed that there is a strong correlation between dentin translucency and age advancement however did not show any correlation with gender.

Conclusion

Studies on butterfly effect observation in the cross sections of teeth for estimation of age are limited. The presence of butterfly effect has strong correlation with age advancement; however, it does not correlate with gender. Although accurate age estimation may not be possible, evaluation of butterfly effect could be an important additional parameter while estimating adult age.

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