

Butterfly Effect in Endodontics: A Systemic Review.

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ABSTRACT: VRF occurs more frequently in buccolingual direction with craze lines, cracks on root sections more common buccolingually. This can be attributed to presence of butterfly effect in some cross sections of tooth roots. Butterfly effect is an optical phenomenon in some cross-sections of tooth –roots. The presence of dentinal tubules causes light to refract and scatter. A decrease in the number of dentinal tubules results in greater light transmission to give a translucent appearance. Occurrence of butterfly effect is most commonly observed in posterior teeth as compared to anterior teeth.

Butterfly effect has clinical significance as it contributes to one of the important predisposing factor for vertical root fracture, affects sealing ability of tooth and also contributes to dentinal hypersensitivity.

Keywords: Butterfly effect, buccolingual, optical phenomenon, vertical root fracture,

I. INTRODUCTION

Vertical root fracture in endodontics is considered as a complex phenomenon as it is multifactorial in nature. No single specific etiology is considered pathognomonic for this complication. And therefore, prevention and treatment of this condition becomes quite difficult. Clinically, up to 31% of root filled teeth are extracted because of VRF.¹⁻⁴The predisposing factors are practically noncontrollable. These include the specific anatomy of the susceptible roots, biochemical changes in the root dentin in the endodontically treated tooth, and loss of healthy tooth substance as a result of caries and trauma before beginning endodontic procedures. The contributing factors are attributed to the iatrogenic risk factors associated with various dental procedures performed on the tooth.

The literature shows that VRF occurs more frequently in buccolingual direction with craze lines, cracks on root sections more common buccolingually⁵⁻⁶. This can be attributed to presence of butterfly effect in some cross sections of tooth roots. Very few articles and studies are available regarding butterfly effect. So the aim of this review article is to understand the concept of butterfly phenomenon and its clinical significance.

What is butterfly effect?

The “butterfly” effect was first photographed by Beust in 1931 as an optical phenomenon in some cross-sections of tooth –roots⁷. Vasiliadis et al reported that dentinal tubular sclerosis differs in the mesiodistal and buccolingual directions, noting a characteristic butterfly shape in transverse sections of the roots caused by different shades of dentin⁸. Sclerosed dentin is more translucent than normal dentin. The presence of dentinal tubules causes light to refract and scatter. A decrease in the number of dentinal tubules results in greater light transmission to give a translucent appearance.

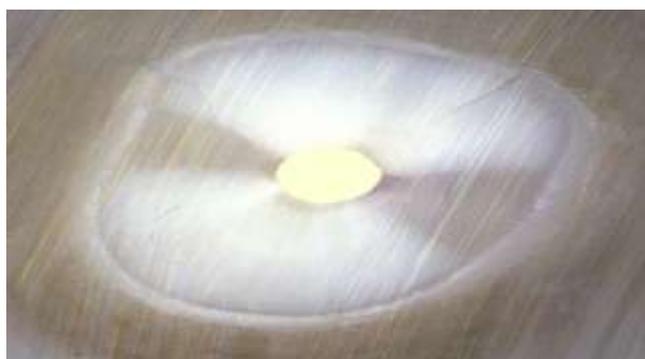


Fig- Transverse section of tooth viewed under light microscope showing butterfly phenomenon

The study done by Assil A. Russell showed that, the density of dentinal tubules was significantly higher in the root sections cut mesiodistally and lowest in those cut buccolingually regardless of the age group and this trend was consistent across all age groups. Butterfly effect is related to sclerosis, but it appears that tubule density also plays a role in formation of butterfly appearance⁹. Nevertheless, the difference in the density of tubules between the mesiodistal and buccolingual aspect throughout the entire length of the root and regardless of tooth age may have significant clinical implications. Investigation shows that teeth with the butterfly effect have lower hardness scores buccolingually than mesiodistally. This potentially helps to explain VRFs occurring more buccolingually than mesiodistally. Also a study of dye penetration in dentinal tubules showed a distinctive barbell-shaped pattern, with more dye entering tubules in the buccolingual aspects.

II. OCCURANCE OF BUTTERFLY PHENOMENON

Von Arx et al examined the different characteristics of root sections and described the presence of “frosted dentin,” which was more common in premolars and molars than in anterior teeth¹¹. Furthermore, there was no difference between age groups. Therefore, the clinical significance of the butterfly effect may be more applicable in posterior teeth¹¹.

M.S. Rama Rao, V.S.S.K. Sekhar, Ch. Kiran Kumar, R. Tejasree Rathod conducted a study on occurrence of butterfly effect in incisors, canine and premolars and concluded that if butterfly effect was present, this was uniform all along the root, and no significant difference is observed in the presence of butterfly effect in incisors, canines and premolars, but with slight predominance in incisors and canines¹².

III. SIGNIFICANCE OF BUTTERFLY EFFECT

1.1 Vertical Root Fracture

The fact that many tooth roots feature the butterfly effect and have higher densities of dentinal tubules and lower hardness scores in the buccolingual direction, regardless of dentin thickness, may help explain the unexpected pattern of VRF. Canal shape and root morphology have been linked to VRF, with ovoid canals associated with higher stress concentration and a greater occurrence of cracks. Mechanical preparation of root canals is known to introduce craze lines and increase the risk of VRF. A smoothly rounded canal is favorable, eliminating stress concentration to decrease fracture susceptibility. Thus, for teeth showing the butterfly effect, conservative root canal preparation and maintaining a circular canal shape may be very significant^{13 14}.

Root canal preparation, ultrasonic irrigation, obturation techniques including lateral condensation of gutta-percha, and post placement may produce unfavorable stresses and crack propagation in canals. Studies investigating cracked teeth have found that there is a significant correlation between VRF and endodontically treated teeth. Even the use of chelating agents such as 17% EDTA for prolonged periods has a significant effect on dentin microhardness, leading to VRF. Therefore optimal care should be taken in teeth exhibiting butterfly effect while doing root canal preparation, ultrasonic irrigation, obturation, post placement, etc. Care should be taken while filing in the bucco-lingual direction to prevent vigorous instrumentation in this area. However, with the use of controlled instrumentation and newer techniques root fractures can be prevented even in the presence of butterfly effect

1.2 Effect On Sealing Ability And Adhesion Of Dentin

This butterfly effect also affects the sealing ability of the resin-based sealers which binds to the dentin by forming resin tags in to the dentinal tubules¹⁵. Variations in the density may surely affect the sealing property of the resin-based sealers¹⁶.

The distribution of the sealer around the root canal, is found to be greater in the bucco-lingual direction and there was no penetration in the mesio-distal direction. The presence of sclerosed dentin and obliterated tubules negatively affects the formation of resin tags required for the adhesion of composite restorative materials. Restorations placed on sclerosed dentin with few dentinal tubules do not perform as well as those placed on dentin with patent tubules. Considering the difference in dentinal tubule density and sclerosis in teeth with the butterfly effect, it seems logical that radicular restorations on buccal or lingual surfaces may achieve better retention and longevity than those on proximal surfaces⁹.

Thus, the use of adhesive resins in root canal obturation may also be compromised in teeth featuring the butterfly effect. Performance of resin-based root canal sealers and the cementation of root canal posts with some luting agents might be influenced by the presence of fewer tubules mesiodistally in tooth root exhibiting butterfly effect.

1.3 Effect On Dentin Hypersensitivity

Dentin hypersensitivity can occur on all tooth surfaces but is mostly on the cervical part of the buccal surface. Investigations of hypersensitivity indicate a range of causal factors including gingival recession,

abrasion, erosion, cracked teeth, bleaching, and genetic predisposition. The greater number of tubules on the buccolingual surfaces of teeth with the butterfly effect may render them more susceptible to hypersensitivity¹⁷.

1.4 Effect Of Antibiotic Paste On Teeth With Butterfly Effect

The microhardness of dentin can vary from the pulpal to the cemental part of the root dentin due to differences in tubule density. The dentin microhardness values decreases after treatment with the calcium hydroxide and antibiotic pastes over all time intervals. The double antibiotic paste shows reduced Knoop hardness number (KHN) values compared with the triple antibiotic paste group. Therefore, antibiotics paste should be used with caution in endodontic treatment in teeth exhibiting butterfly effect¹⁸.

IV. Conclusion

Root sections with the butterfly effect have a lower density of tubules mesiodistally, and thus have much clinical significance in endodontics and conservative dentistry. Tooth with butterfly effect undergoing root canal treatment should be carefully instrumented as it has increased chances of vertical root fracture and also shows reduced sealing ability.

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