Review Article

The Advent of the Compression Dome Concept

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ABSTRACT

A detailed understanding of the histoanatomic structures and active interaction of the natural dentition provides dentists with the optimum decisive advantage with regard to fabrication of the final restoration. The article attempts to provide an overview of the protective structure naturally present in the tooth. The concept of a "peripheral rim of enamel" and the manifestation of compressive and tensile fractures within the peripheral rim of enamel and dentin has been described. Enamel acts as a stress distributor. The load is transferred to the root vertically and horizontally to the crown by means of the dentinoenamel junction. A DEJ is a thicker zone that undergoes greater stress than the central coronal dentin. The conventional cavity designs are disharmonious with the tooth's natural mechanical stress distribution system. This philosophy prompts the use of modern methods of caries detection for early accurate minimal intervention in the caries process. This helps to preserve internal mechanical structures within the tooth that is vital to its long-term mechanical viability. The mechanical insult on the tooth leads to weakening of the healthy tooth complex as well as loss of tooth structure. When the forces exceed the clinical parameters, the tooth starts to breakdown leading to ultimate fracture. The article also emphasizes on the various treatment modalities and the use of minimally invasive and adhesive technologies to maintain the integrity of the tooth and protect it from future damage. The prosthodontist should attain keen knowledge of the tooth and how it responds to the intraoral exertions.

Key words: Compression dome, dentinoenamel complex, tooth structure

INTRODUCTION

The fundamental tooth structure comprises enamel, dentin, cementum, and pulp [Figure 1].[1] Enamel is the hardest known substance in the human body, and it safeguards the inner dentin from the deleterious forces.[2] The human teeth were originally designed to sustain the vertical compression forces, which when subjected to tension, undergo crack propagation with eventual pain, fracture, and depletion of tooth structure. The current upgraded comprehension of the tooth microanatomy in concurrence with diagnostic and restorative advancements has revolutionized dentistry which refurbishes the tooth such that it very intimately relates to the healthy tooth form both functionally and biomechanically.[3] The dental professional strives to imitate the naturally intact tooth very closely, with the myriad of shades, translucencies, opacities, effects, and stratification techniques available.[4] Customarily, prosthodontists have been designing full coverage restorations for severely mutilated and root canal treated teeth. This technique causes removal of enamel and exposure of underlying dentin to bear the troublesome tensile forces, for which the teeth were not structurally designed to bear. The exposure of dentin may lead to flexural pain, crack propagation, and ultimately fracture in future. Evidence now supports that just like the dome of a cathedral, tooth is shaped like compression dome. The functional zones on a tooth are the "Bio Dome" and "Bio Rim." The Biodome is the coronal half of the compression dome and the cervical half of the tooth below the contact area that supports the coronal compression dome is being called the Bio-Rim. The priority of the prosthodontists should be on preserving the Bio-Rim as much as possible, within the boundaries dictated by existing damage from previous restorative efforts, trauma, or decay. The preservation of Bio-Rim should be the highest aim of the restorative dentist, which is otherwise broken down while placing a crown. An adhesive onlay restoration retains the Bio-Rim and helps to recreate the Bio-dome and restore biomechanical function.[5]

THE NOTION BEHIND THE ENAMEL COMPRESSION DOME

With the evolution in dentistry, the teeth have not evolved enough to sustain the insult caused by dental procedures.[3] The enamel is

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designed in such a way that it protects the tooth like a compression dome just like the dome of a cathedral [Figure 2].[6] It passes on and transmogrifies the forces into a primarily compressive force on the dentin along the dentinoenamel complex.[7] The compression dome houses several microstructures that absorb and dole out the forces such as the maxillary web of enamel, the peripheral rim of the enamel, and the subocclusal oblique transverse ridge [Figure 3].[8,9] According to recent reports, the intracollagenous nanocrystals of hydroxyapatite in dentin collagen fibrils keep the fibrils in tension, acting like a pre-stressed reinforcing steel in concrete, keeping the surrounding hydroxyapatite hard structure in compression.[10] A boon to the teeth is the dentinoenamel complex that comprises two thin layers of aprismatic enamel and mantle dentin.[11] The interface ensures stress transfer thereby shielding the dentin from the demeaning tensile forces and maintaining it in a compressed state. At the microscopic level, a biscalloped surface topography is evident, establishing a complex zone capable of plastic deformation while being collagen fibril reinforced.[12] The duo results in a tooth structure that can last lifelong.[3]

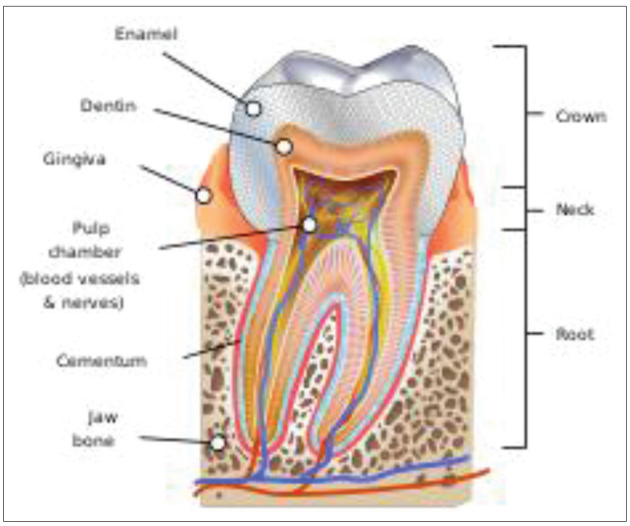

Figure 1: Parts of the tooth

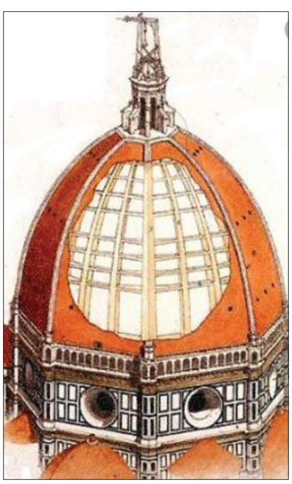

Figure 2: Dome of a cathedral

OUTCOME OF COMPRESSION DOME VIOLATION

The enamel at times acts as a brittle glass and sometimes as a viscoelastic material.[13] Once the compression dome is disrupted beyond the clinical parameters the tooth starts to flex and distort. Under the effect of tensile forces, there occurs vertical fracture in the peripheral rim of enamel that leads to occlusal effect caries.[6] Elimination of the cross-bracing structure like the subocclusal oblique transverse ridge during tooth cutting, subjects the dentin to distortion due to compressive stresses on the compression dome of enamel that predisposes the marginal ridges to tension, and results in vertical tooth fracture.[3] Weak pathways between the enamel prisms act a route for crack propagation and deformation.[14] Violation of the compression dome most often results in an oblique fracture. The occlusal inclined planes on loading lead to tension on the dentin. The sharp internal line angles act as areas of stress concentration causing stress propagation and fracture of the cusp. A less common type of fracture is the mesiodistal vertical fracture due to opposing plunger cusp. Even an untreated tooth may result in fracture under tensile forces, thereby indicating that teeth cannot cope well with tensile forces. When a fracture is left untreated, it may propagate to the pulp.[3]

RATIONALE

The primary goal is to maintain the integrity of the compression dome to avoid mechanical encroachment and breakdown of the tooth complex.[3] Change in dietary habits which leads to an unhealthy biofilm and extended periods of low pH are the sole cause behind tooth caries.[15] Changes cannot be forced but human intervention overtime can lead to an evolutionary shift. The need of the hour is to educate the patients to regain a healthy biofilm through dietary modification so that the healthy commensals can repopulate the oral cavity.[16]

TREATMENT OPTIONS

The enamel compression dome can be preserved by availing any of the following restorative alternatives:

Pit and fissure sealants

The occlusal pits and fissures are the critical sites for caries progression. At the same time, they are also the crucial areas for preservation of the compression dome. Early diagnosis and intervention are of prime importance.[3] The fissures are to be thoroughly debrided and packed with a pit and fissure sealant containing fluoride, amorphous calcium phosphate or nanohydroxyapatite, or low viscosity resin infiltrant with a flowable composite resin.[17] The technique resembles placement of windows within the cathedral dome that do not interfere with energy compression pathways. However, if the windows of the

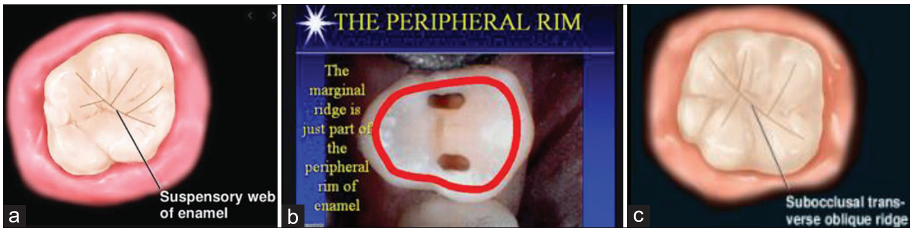

Figure 3: (a) Maxillary web of enamel, (b) peripheral rim of enamel, (c) subocclusal oblique transverse ridge

dome, that is, the cavities are too large, the dome could collapse. Delayed intervention causes loss of major tooth components.[18]

Bonded restorations

Bonded restoration furnishes ample amount of support to the tooth by disseminating the forces and cutting down on the incidence of crack propagation.[18] Bonded ceramic partial crowns are considered appropriate for posterior teeth. The main noted failures were fractures. The stronger lithium disilicate glass ceramics reinforced with zirconia are ideal materials for bonded ceramic restorations.[19] Bonded ceramic preparations should emphasize on the following principles: An uniform thickness of material (1.5–2 mm), avoidance of sharp angles, exemption of high tensile stresses by converting them into compressive forces by transformation in the preparation design, and elimination of stress peaks by smooth transition.[20]

Composite restorative materials

The key factor is the bonding material used. Composite material results in the longest and most durable bond. Adhesion of composite is mainly by micromechanical or chemical bonding. The strongest luting composite should be chosen to provide support to the crown.[21] Moreover, the microtensile bond strength of light curing composite is high and can be used for luting crowns.[22] Panavia dual-cure composite is a fluoride containing highly adhesive composite recommended for luting crowns.

Adhesive cements

Documented gold standard adhesives are 3-step etch and rinse adhesive Optibond FL and mild 2-step self-etch adhesive Clearfill SE Bond.[23] Following polymerization of adhesive, a layer of highly filled flowable composite is used to block the micro undercuts in the dentin. It stabilizes and protects the newly formed hybrid layer.[24] The current adhesive materials also assist in replicating the natural enamel dentin bond strength at the dentinoenamel complex.[25] Smaller restorations suffice with simple monophase adhesive restorations. In larger cavities, fiber-reinforced composites and high-molecular-weight polyethylene fibers that have been recently developed can be used to relieve the stress related depletion of the tooth.[26]

Onlay restorations

Adhesive ceramic on-lays are excellent at rebuilding the compression dome. Tensile strength ranges between 40 and 50 MPa comparable to that of dentin and enamel, that is, 45 MPa.[24] The evolution in material science has led to invention of materials that help restore the biomechanical function of the tooth without cutting away the sides of the tooth. This is related to the new term "Bio-rim." It is the area of the posterior tooth that lies beneath the maximum area of convexity. When the occlusal enamel is considered the compression cathedral dome, the walls surrounding it is the Bio-rim. Retention of the Bio-rim significantly minimizes the severity of tooth breakage as compared to the risk associated with removal of entire tooth structure while preparation for a full crown.[27] To rebuild the enamel compression dome, traditional cementation techniques are left out to be replaced with adhesive cements and on-lays. The amalgamation of the adhesive technology with the high strength ceramic on-lay aids in recreating a fully laminated structure in close resemblance to that of the natural tooth.[28]

Occlusal veneers

Satisfactory results were obtained from *in vitro* occlusal veneers for restoration of occlusal wear. Thicknesses should be 1.5–2 mm and are especially effective when bonded to enamel.[29]

CONCLUSION

The new era of restorative dentistry necessitates commitment toward adhesive technology. The natural enamel compression dome is strongly adhered to the dentin and peripheral enamel. The quest for knowledge and precision has routed toward better and stronger materials that unify the tooth restoration complex to closely mimic that of the natural tooth. In addition, an important concern is the amount of remaining tooth structure that determines the magnitude of pulpal reaction and tooth longevity. Long-term prognosis of a restoration demands decision-making that indicates use of specific cavity designs and materials that help conserve maximum tooth structure and reinforces the naturally occurring enamel compression dome.

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