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Abfraction: Etiology, Treatment and Prognosis

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Abstract Sound teeth constitute the main component of esthetic smile. Lesions affect the facial aspect of the teeth have their drawbacks on the individual psychological status. Abfraction affects the gingival third of the teeth on the facial surface. It mainly affects premolars and anterior teeth. Bacteria have no role in abfraction, so it may affect individuals with good oral hygiene. The aim of this review is to throw lights on the etiological causes of this lesion and possible treatment modalities. **Overview**: Many hypotheses describe the possible etiology of abfraction. Tooth flexure hypothesis is the most accepted one. This hypothesis assumed the occlusal load as the causative factor for abfraction as the occlusal stress concentrates at the thin enamel of the gingival third of the tooth, so enamel fractures leading to formation of wedge-shape cervical defect. This hypothesis is confirmed by the result of finite element analysis studies. Other hypothesis suggested abrasion due to tooth paste as the causative factor of this lesion, while other one suggested the erosive potential of acidic drinks. Most researchers believe that it is multifactorial disease. Many materials have been used to restore this defect. These materials include composite resin, glass ionomer, resin modified glass ionomer, direct gold, amalgam, and full coverage restoration. Each one of these materials has its advantages and disadvantages and the dental practitioner has to decide which one is more suitable for the specific condition of the patient. **Conclusion**: The real cause for its development is controversial till now. The choice among available restorative materials depend a great extent on the patient esthetic demand. Further study of this lesion is required.

Keywords: *abfraction, abrasion, erosion, non-carious cervical lesions (NCCL)*

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1. Introduction

The cervical third of tooth crown constitutes integral part of the smile esthetics. Unfortunately, this critical region may be affected by carious or non-carious lesions. Non-carious lesions (NCCL) are those defects affected the tooth with no bacterial involvement. These lesions include abrasion, erosion, and abfraction [1,2]. The cause of these NCCL may be mechanical or chemical [3]. Mechanical wear of tooth structure leads to attrition, abrasion, and abfraction, while chemical wear leads to erosion [4]. All these lesions are chronic in nature [5,6]. The differentiation among these types constitutes a challenge for dental practitioners [7,8]. To achieve accurate diagnosis the dental practitioner should combine the clinical picture of the lesion with the etiological factors mainly parafunctional occlusal habits [9,10,11].

This term (abfraction) was first introduced by Grippo in 1991 [10,12]. He used this term to distinguish abfraction from other tooth defects that may result from other causes [10]. Before this date it was termed as idiopathic erosion cervical lesion [13]. However, the description of the abfraction itself has been described earlier in 1930 [14]. Abfraction can be defined as a physical process resulted from biomechanical occlusal stress concentration at the cervical third of the tooth leading to ditching at the cemento-enamel junction due to crack formation [12,15,16,17,18]. It is considered as a fatigue failure of hard tooth tissues resulted from occlusal loading which leads to tooth flexure [19,20]. These loads may be static as in case of chewing or cyclic as in case of mastication [21].

2. Morphological Characteristics

Abfraction occurs at the cervical region of the tooth on the facial surface [12]. They are wedge-shape with the depth more than the width and sharp internal boundaries [3,22]. The border of the abfraction lesion are almost sharp and well defined [23]. The occlusal and gingival walls of abfraction lesion converge in a pulpal direct to meet in line angle [3]. The etiological factors affect the final shape of abfraction to great extent [24]. Others shapes of abfraction also have been recognized including hairline cracks, striations, saucer-shaped lesion, or crescent-shaped lesion [10]. This leads some researchers to classify abfraction lesions according to its shape into three categories; c-shaped lesion, v-shaped lesion, and mixed lesions [25]. Abfraction is usually accompanied with gingival rescission [26]. Although most of abfraction lesions located supragingivally, subgingival lesions also may occur [27]. In other words, these lesions occur at the fulcrum of tooth flexure when the applied load exceeds the flexure strength of the tooth [28].

3. Histopathology

SEM study of abfraction lesions shows damage of dentin even in the presence of intact enamel near the cervical margins. The dentinal tubules are not visible and covered by smear layer. In the beginning of the lesion the dentinal tubules are patent but with progression these tubules become less in number and covered by smear layer. It shows the surface of the lesions exhibited some scratches which may be due to accompanied abrasion [3]. Abfraction not only leads to ditching at the cervical area of the tooth but also leads to compositional changes in dentin of the affected area. The super facial dentin of NCCL is hyper mineralized to a depth of 10um with underneath denatured collagen and partial or complete occlusion of the dentinal tubules with mineral deposits [4,39].

4. Hypothesis

Awareness campaigns and the provided dental preventive measures have been resulted in marked improvement in the oral hygiene [40]. However, once the tooth is erupted in the oral cavity, it is subjected to normal and physiological loss of surface enamel by about 11um/year [41]. This rate may be increased with parafunctional habits [19]. Knowing the exact cause of abfraction may lead to change in the restorative techniques of these lesions [20].The most accepted theory is the tooth flexure. This theory postulated that transmission of the occlusal forces through the axial walls of the tooth to be concentrated at the cervical region causes high tensile stresses at this area [12,13]. This theory was first hypothized in 1984 by Lee and Eakle [28]. This theory can be simply interpreted on the basis of biomechanics. The tooth and its supporting tissues act as class III lever, with a fulcrum between the cervical third and the crest of alveolar bone, so the loads applied to the cusp tip will be magnified and concentrate at the fulcrum to a level exceeds the flexure strength of enamel leading to enamel fracture at this critical region [21]. These stresses are higher in eccentric movements, and in enamel than in dentin [12]. In addition, the enamel at the cervical region subjected to lateral stresses 4 folds greater than axial stresses [14]. These stresses increase with parafunctional habits as bruxism or occlusal interference [21,30]. These lateral stresses are more than 17mpa, the maximum stress enamel can withstand [42]. The cyclic loading during mastication leads to degradation of the chemical bonds among hydroxyl apatite crystals of the tooth hard tissues, with subsequent penetration of small molecules that prevent these bonds from re-establishing again [21,29,37]. Although during mastication compressive, tensile, and shear stress are generated, according to finite element studies, tensile stresses are the causative factors for abfraction as theses stresses concentrate at the gingival third of the tooth [14]. Abfraction lesion results due to undermining of enamel when stresses concentrate at the tooth cervix [4]. This theory is confirmed by Jakupovic et al who found stress concentration at the subsurface enamel was greater 5 times more than that at superficial enamel [12]. This is may be due to the inferior structure of deep enamel when compared to superficial enamel [43]. Once the lesion is initiated, the formed notch leads to more stress concentration at this defected area [44,45]. Also, Van Meerbeek et al confirmed the stress concentration at the cervical region as the cause of abfraction lesions [46]. This hypothesis is confirmed also by the results of Benazzi et al who found that cusp inclination dictates the direction of the occlusal forces to be concentrated as a tensile stresses at the cervical third of the facial surface of the tooth [47]. In deed what strengthen this theory are the rare cases of abfraction in periodontally affected teeth as they receive reduced stresses and if occurred it would be away from the cervical third in apical direction [48,49,50]. On the other hand West et al disagreed with stress concentration hypothesis, explaining his view that there are teeth suffering from traumatic occlusion but do not have abfraction lesions [18].

Roomed et al suggested the role of bruxism in the development of abfraction [14]. This suggestion is reinforced by the result of another study [21]. Bruxism means clinching of opposing teeth together in absence of food [51]. Its prevalence is about 5-8% in general population [52,53,54,55,56]. It may occur unconsciously during sleep [19,57,58]. Individuals with anxiety disorders or have greater stresses are more susceptible to sleep bruxism [59,60]. Borčić et al assumed that the stress intensity applied to the tooth in a certain period of time may lead to fracture of the tooth hard tissues [61].

Finite element analysis was used by several authors to study stress concentration at the tooth cervix [12,13,14,62,63]. The majority of these studies were performed on a model for lower premolar, however other researchers have used the upper canine as a model in his study [14,64,65,66]. The results of these studies confirmed the occlusal load as the cause of abfraction lesion. On the other hand Sadaf et al conducted a cross-sectional study and he found no significant association exists between neither the occlusal load nor the eccentric forces and the cervical lesions, and concluded that occlusal forces are not the main cause for NCCL [20]. This result is confirmed by other studies which found abfraction lesions in teeth subjected to light occlusal loads [29,67]. In the same line, Levrini et al supposed the cause of abfraction lesion to be direct impact to the affected area [3]. He suggested dissipation of the occlusal stress through the dentinal tubules, so the stress could not reach the cervical region. Also, Finite element analysis suggests the cervical lesion to be located both facially and lingually, a situation does not exist clinically whereas abfraction lesion occurs on the facial surface only of the teeth [20,68]. This hypothesis can be challenged by the fact that, direct trauma to the teeth may result in tooth fracture rather than abfraction lesions.

Other researchers believe that hard tooth brushing with abrasive tooth pastes leads to the formation of these lesions and termed the lesion as tooth brush abrasion [28,64,68,59,70,71]. This hypothesis is evident by Adeleke et al who found most of these lesions occurred in the upper jaw and explained this result by the fact that most of individuals start tooth brushing from the upper jaw with excessive force which decreased gradually [7]. This hypothesis is rejected by other researchers who noticed that abfraction lesion did not occur in deciduous teeth, although they brush their teeth [47].

Another hypothesis throws light on the erosive potential of acids to weak the thin cervical enamel thus contributing in the formation of abfraction [14]. Karanet al speculated combination of chemical erosions and mechanical stresses in development of wedge-shaped cervical lesions [72]. Bhagabati et al suggested the effect of two or more etiological factors to initiate NCCL [8]. Most of the researchers believe that abfraction lesion is a multifactorial lesion in which erosive and abrasive components play a role beside the occlusal forces [23,27]. On the other hand as abfraction usually occurs in middle age and increased in size with aging [7,31,32]; this result has prompted some researchers to believe that it is normal physiological process [24].

Indeed, none of these theories has been approved till now [30]. This is may be due to lack of sufficient clinical studies supports the effect of occlusal forces on the cervical region of the tooth [27]. Due to insufficient data till now regarding the development of abfraction lesion, the study of such lesion is continuous. [7].

5. Treatment

Abfraction leads to exposure of dentin to the oral environment with subsequent hypersensitivity and impaired esthetics [18,20,30,31,73]. Indeed, abfraction lesions usually shallow, but with greater occlusal load they tend to enlarge with the possibility of pulp involvement [3,29]. All these reasons push dental practitioners to restore these lesions [30]. Indeed, the cervical restoration survives less than restoration in other areas of the tooth [74,75]. This is mainly attributed to the presence of sclerotic dentin and the concentrated occlusal forces at this critical area [76,77,78].

Proper diagnosis leads to proper management. This can be accomplished through careful clinical examination focusing on the etiological factors and past medical history of the patient [24]. Early detection and treatment of abfraction lesion prevent enlargement of the lesion [14]. The size of the lesion determines the treatment plan to a great extent. While minor lesion may require no treatment, larger ones require corrective restorative treatment and in sometimes accompanied by occlusal corrections or gingival surgery [1,14,30]. If these lesions are left untreated further damage to the tooth structure would occur, while if it is restored properly, the stress concentration would decrease with subsequent preservation of the tooth structure [79].

Prior to treatment, determination of the lesion activity is very important. Nascimento et al and Shetty et al suggested the use of no. 12 blade to determine the activity of abfraction lesion. A scratch is made on the tooth and if this scratch disappears this means the lesion is active one [24,27]. Also, tooth wear index developed by Smith and4R Knight can be used to monitor the activity of abfraction lesions. They noted the change in the tooth contour and the depth of the lesion and gave a score from zero to four according to the case; score zero for minimal lesion with no change in the tooth contour, score 1 for minimal loss of tooth contour without cavitation, score 2 for lesions less than 1mm depth, score 3 for lesions from 1mm to 2mm depth, and score 4 for lesions more than 2mm [80]. Periodic photographs and study models for monitoring the lesion is also helpful [24,30]. Follow up of the initial lesions should be considered, and If the lesion propagates, restorative intervention should be done [30].

Restoration of abfraction lesion constitutes a challenge to dental practitioners [81]. The exposed cervical dentin is hyper mineralized with low bond strength with the bonding agents [82]. This problem is exaggerated by the absence of adequate mechanical retention [76]. Another obstacle is the difficulty to obtain dry field in this critical area [17]. All these challenges lead always to secondary caries around the boundaries of cervical restorations [81].

Restoration dislodgement is another manifestation of failure. Both decreased bond strength to sclerotic dentin and cyclic occlusal loads play significant role in dislodgment of these restorations [81]. Also tooth flexure at the cervical third not only leads to dislodgment of class v restorations but also microleakage and pulpal sensitivity [50]. when dental practitioner decides to restore this defect, he or she should select the restorative material that gives the smoothest surface after finishing and polishing to prevent plaque accumulation with subsequent increased chance to develop periodontal disease or even caries [66,83,84].

Field isolation is mandatory in restoring cervical lesion. This can be accomplished by various techniques include, rubber dam, gingival retraction cords, and in some cases gingival surgery may be required to expose the gingival margin of the cavity. Application of rubber dam is the best technique; however it may be difficult due to limited access for some cases, in this situation the practitioner has to use another suitable technique [30].

The effectiveness of the restorative material is measured by its ability to survive for a longer time [39]. The choice among different available restorative materials depends a great extent on the patient's demands and the esthetic quality of the restorative material as well as its ability to maintain a polished surface [17]. Composite resin and glass ionomer are the most used materials to restore non carious cervical lesions (NCCL) [13,85,86,87,88]. Whatever the used material to restore these lesions, good finishing and polishing should be carries out to achieve as smooth as possible surface that prevent or decrease plaque accumulation potential [30].

Glass ionomer was introduced in 1970 by Wilson and Kent [89]. The advantages of glass ionomer include biocompatibility, fluoride release, good bonding, and coefficient of thermal expansion close to that of the tooth [88,90,91,92]. unfortunately, glass ionomer is very sensitive to water contamination before complete setting with subsequent adverse effects on its properties, so it should be isolated for 24 hours after restoration procedure [90,93,94]. On the other hand the abrasion resistance of well performed glass ionomer restoration is very high, also [17]. Lack of enamel margins near the gingiva give glass ionomer the opportunity to be the first choice for dental practitioner as beveling of the margins required for composite resin restoration cannot be done [17]. When comparing the clinical performance of glass ionomer to composite resin, it was found that their performance are very closed to each other and, moreover, the cervical glass ionomer restoration lasts for longer periods than composite ones [7,82,88,95,96,97]. Lambrechts et al showed a survival rate of glass ionomer restoration of 90-100% after three year observation [98].

Resin modified glass ionomer were introduced in 1990 to overcome the limitations of conventional glass ionomer and to obtain better translucency, higher early strength and more controllable working time with fast setting [99]. It bonds to the tooth structure by two mechanisms, first chemical bond and second hybridization [100]. it has good performance in NNCL. This is confirmed by a 91% survival rate of resin modified glass ionomer when compared to 74% survival rate of resin composite after one year [7]. He explained his result by the chemical bond between the tooth structure and resin modified glass ionomer as well as the relatively equal coefficient of thermal expansion, while the higher failure rate of composite resin was related to its stiffness. Srirekha et al assumed the good performance of resin modified glass ionomer to its modulus of elasticity which permits bending of the material when the tooth is subjected to tensile stresses [36]. Contrary to this assumption N Shubhashini et al concluded better performance of materials with higher Young's modulus in restoration of class v cavities. They performed finite element analysis study for the performance of four restorative materials in class v cavities and found the best performance was recorded for microfilled composite followed by flowable composite and resin modified glass ionomer respectively, while the worst performance was recorded for conventional glass ionomer [22].

Both giomer and nano-ionomer are results of the continuous development of resin modified glass ionomer. Nano-ionomer is a resin modified glass ionomer with more than 60% nano-sized fillers. This material has better mechanical performance than conventional glass ionomer cement with high surface polish, color stability and high wear resistance [101]. Giomer is a combination of glass ionomer with resin composite in which the filler particles are pre-reacted glass fillers [100]. Bollu et al compared microleakage in cervical cavities restored with nano ionomer, resin modified glass ionomer and giomer and found the least microleakage scored for nano-ionomer while giomer exhibited the highest microleakage score [92]. He attributed this result to the chemical bond between tooth structure and nano-ionomer. However the advantages of glass ionomer and its derivatives, some researchers consider composite resin as the best restorative material for abfraction lesion [30].

Nowadays, composite resin is the most favorable restorative material for the dental practitioners due to its mechanical and physical properties which allow for functional and esthetic restoration [31]. It constitutes the main material used to restore cervical lesions [32,102]. Unfortunately, absence of resin tags was observed in such lesions as phosphoric acid fails to both etch peritubular dentin and dissolve the mineral deposits inside the lumen of the dentinal tubules with subsequent lower bond strength than normal dentin by about 20-50% [39,72]. Other problem associated with resin composite is the marginal gap resulted from polymerization shrinkage that cannot be compensated by water sorption [22]. Microhybrid composite is the most used restorative material in dentistry nowadays and frequently used in NCCL. Prevention of secondary caries is a main goal when restoring cervical defects. This is performed through decreasing the possibility of plaque adherence to the surface of the restoration. Microhybrid composite neither alters the bacterial flora nor increases its growth. This result is confirmed by in-vitro study which indicates lower bacterial growth on microhybrid composite discs [31]. To combine the advantage of low young's modulus and chemical bonding to tooth structure of glass ionomer with the superior esthetic of composite resin, sandwich technique was used to restore abfraction with resin modified glass ionomer as the first layer over layered with resin composite [1].

Occlusal loads leads not only to cervical bending of the tooth but also bending of the composite restoration and adhesive bond [103]. A composite with low Young's modulus is used to restore this lesion as it bends with the tooth flexure [74]. Microfilled composite and flowable composite are the materials of choice [104,105,106,107]. Another approach is to use flowable composite as stress absorber [108,109,110]. The bond strength at the tooth-restoration interface should be greater than the applied occlusal stress transmitted to it; otherwise restoration dislodgment is anticipated [13]. A thicker hybrid layer reduces the stress distribution into the tooth-restoration interface [13,111,112]. It is believed that hybrid layer act as stress absorber for both polymerization shrinkage stress and occlusal stress [113,114]. This is confirmed by the results of Srirekha et al who attributed his results to the formation of adhesive layer leading to increase in the strain capacity [36]. Eliguzeloglu Concluded tow functions of hybrid layer; first bonding to tooth hard tissue, and second decrease the shear stresses in the cervical region [13]. these functions are also confirmed by other researchers [81,115,116,117]. The structure of hybrid layer is elastic one [46,118,119,120,121]. It is composed of partially demineralized dentin infiltrated by adhesive resin [81]. It is advisable to use carbide burs for cavity preparation in the cervical region as it will result in thicker hybrid layer [122]. The occlusal stress concentrates at the gingival margins of cervical restorations more than at the occlusal margins and on the same time at the external surface more than at the interface, and in the same time hybrid layer decreases the stress intensity of the occlusal forces at the cervical region, while acting as a cushion beneath the restorative material [81].

The use of amalgam and gold to restore cervical lesions was performed in the past but nowadays these materials is not used any more due to the increased demands for esthetic restorations [92]. Full coverage crowns also have been used [123]. The main disadvantage of full coverage crown is the gross destruction of the natural tooth tissues to be replaced by prosthetic appliance.

Another treatment modality is the occlusal adjustment. Occlusal adjustment is beneficial in decreasing the unfavorable tensile stresses at the gingival third [30]. This assumption is encouraged by the result of Benazzi et al who found flattening of the cusps leads to reducing the tensile stresses to the facial surface and directing it toward the proximal surfaces [47]. On the other hand by applying occlusal adjustment treatment we take the risk of caries and dentin hypersensitivity as a result of cutting in the overlying enamel [66]. Implementation of occlusal adjustment procedure should be limited to remove the points of interference while maintaining the centric occlusion points and performed only by professional one [30]. Another occlusal adjustment procedure involves change of the canine guidance directly by adding resin composite, unfortunately this leads to increase stresses applied on the canine [30]. Occlusal splints have been used to prevent both initiation and propagation of the abfraction lesion by reducing the amount of stresses delivered to the cervical area of the tooth [30]. While Perez Cdos et al [30] considered this treatment as effective and conservative one, other researchers disagree with this view. They claim that there is no evidence base to use occlusal splints in the treatment of abfraction [66,124]. Unfortunately, all these treatments deal with sign of the disease not with the etiological factors [30].

6. Conclusions

Abfraction affects individuals of middle age an older. the real cause for its development is controversial till now. Multiple restorative materials are used nowadays to restore such defects. The choice among these materials depend a great extent on the patient esthetic demand and the experience of the dental practitioners. Further study of this lesion is required to establish the real and specific cause so the treatment modalities may be altered.

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