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RESEARCH ARTICLE

FIBER-REINFORCED COMPOSITES AS THE 4TH GENERATION BONDED RETAINERS IN ORTHODONTICS

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ABSTRACT

The enigma of relapse has prevailed in orthodontics since early 1900s. Good stability of an orthodontic treatment relies on proper planning of retention protocol. Many retention protocols are in use by various clinicians, the most common being fixed lingual retainers since the degree of relapse is highly unpredictable. Bonded retainers offer advantages compared to conventional removable retainers in that they are invisible from the front, require less patient cooperation, and provide a long-term or even permanent retention. Various techniques of fixed bonded retainers with different materials have been described in the literature. Glass fiber retainers were introduced to replace the conventional metal wires as fixed lingual retainers. They were proposed to provide better esthetics, easy handling, and biocompatibility as well as improved mechanical strength required for retention. The clinical reliability of Fiber Reinforced Composite retainers still remains questionable and its popularity as the "4th Generation" retainers is limited. The purpose of this paper is to review the rationale of the use of fiber reinforced composites as lingual retainers. Their clinical efficacy, success rate as well as periodontal and oral hygiene status has been discussed. Conclusion: Bonded fiber reinforced lingual retainers cannot be presently considered as the "4th generation." Despite being more esthetic, biocompatible and better retentive strength, the glass fiber retainers are more technique sensitive, expensive and have questionable clinical effectiveness. The multistranded or twisted stainless steel and other wire retainers still are most commonly and widely used.

INTRODUCTION

Background

The importance of retention after orthodontic treatment is well recognized since early 1900s. Good stability of an orthodontic treatment relies on proper planning of retention protocol. The practice and the theory of orthodontic retention therapy have changed and continue to change over the years. Many types of appliances have been used for the retention of post-treatment position of teeth including banded fixed appliances which were later followed by removable retainers. A new era of Bonding in dentistry was heralded by Buonocore (Buonocore, 1955) with the introduction of acid-etch technique and it was Kneirim (Kneirim, 1973) who first reported its use to construct bonded fixed retainers. Plain round orthodontic wires were used initially, but Zachrisson (Zachrisson, 1977) published the potential benefits of using multistranded wires for constructing the bonded retainers. Thus with time fixed lingual retainers gained popularity and clinical acceptance. By 1995, we had three categories of bonded lingual retainers as described by Zachrisson B. (Zachrisson, 1995) based on the design of retainer bars:

- The **first-generation** mandibular bonded lingual 3-3 retainer was a plain round .032- to .036-inch blue Elgiloy wire with a loop at each end for added retention.(Figure 1a)
- The **second generation (Fig. 1b)** was a twisted, 3-stranded .032-inch SS wire without terminal loops. However it proved less rigid and got distorted, and was also difficult to bend for optimal fit. These drawbacks were eliminated in third generation.
- The **third generation (Fig. 1c)** was a plain round .030- to .032-inch stainless steel (SS) wire, with both ends sandblasted with 50- to 90- μ m aluminum oxide particles to increase the micromechanical retention.

During the last decade, due to an upsurge of Fiber-Reinforced Composites (FRCs) as an alternative in esthetic metal-free dentistry, glass fiber retainers also gained acceptance as orthodontic retainers. In 1987, Diamond and in 1990,Orchinintroduced glass fiber to efficiently replace the removable retainers and lingual-bonded multistrandedwire retainers. (Diamond, 1987; Orchin, 1990) These glass fibers were esthetic, easy to handle, require less maintenance andwith better retention. Biocompatibility is not affected as it can be with nickel-containing stainless steel and other metals. Another advantage of theglass fiber ribbon is that the complete breakage of the retainer does not occur frequently and it can be easily repaired. However, its main disadvantage is producing a rigid

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splint that limits the physiologic tooth movement which may contribute to a higher failure rate. (Nikhilanand et al., 2011; Raju et al., 2012)

FIGURE 1. Three Generations of Bonded Retainers (Zachrisson,1995)



Figure 1a. 1st Generation



Figure 1b. 2nd Generation



Figure 1c. 3rd Generation

FIGURE 2: A Clinical Case



Figure 2a. Patient with Broken 3-3 twisted SS wire retainer (2nd generation)



Figure 2b. DentaPreg (S2-Glass) bonded 3-3



Figure 2c. 7 months post-retention. Visible stains and plaque retention

Main Text

Can we consider the fiber reinforced composite retainers as the 4th Generation?

The clinical reliability of Fiber Reinforced Composite retainers still remains questionable. Among the studies published so far, a few have considered all the factors pertaining to clinical success at one time. Additionally most of studies are in-vitro and experimental in nature. The purpose of this paper is to review the rationale of the use of fiber reinforced composites as lingual retainers. Factors for clinical acceptance have been reviewed under clinical efficacy, success rate as well as periodontal and oral hygiene status.

Flexural and Bond Strength

It has been shown that flexural and shear bond strength is increased by glass fiber reinforcements. A study by Vallittuet al. (1999) found that unidirectional and woven glass

fibres considerably enhance flexural properties of acrylic resin polymers, which was, according to Bae et al. (2001), due to proper impregnation of fiber with polymer matrix as well as composite resins. Comparison between bond strength of a SS orthodontic wire versus various FRC used as orthodontic retainers by Foek et al. (2009) found no significant difference between the two. Juloskiet al. (2012) concluded that the flexural strength of FRC is significantly influenced by fiber composition and pattern. An in-vitro determination of the mechanical properties of fibre orthodontic retainer by Armando et al. (2012) proved the glass fibres to correspond to the requirements of an orthodontic retainer having 10 and 100 times more strength than clinically required. Also the fibre bundle was shown to be sufficiently strong to oppose the occlusal forces. However, this type of "rigid splinting" produced by the glass fibres would limit the physiologic tooth movement which may contribute to higher strain level in interdental areas under masticatory forces thus resulting in a higher failure rate.

Clinical Reliability and Failure Rates

Studies done to evaluate the clinical reliability of fiber retainers show conflicting results. While the earlier studies done by Rose (2002) and Tackenet al. (2002) concluded that the direct-bonded multistranded wire was superior to the fiber retainers, they maintained that the multistranded retainers should remain the gold standard for orthodontic retention and the use of glass fiber retainers should be discouraged in daily practice. On the other hand, recent long-term studies by Bolla, Cozzani et al. (2012) and Sfondrini et al. (2014) showed no significant difference in the bond failure rates of GFR resin composite retainers and multistranded metallic wires over 6-years and one-year follow up, respectively. Bolla also highlighted the use of a rubber dam, a high abrasion resistance composite, second light-curing with "oxiguard" insulation and extreme incisal placing of the retainer as critical factors in the long-term success of the GFR retainers. Limited clinical studies have shown that there is a relatively high failure rate ranging between 2.9% to 47% in a comparatively short follow-up period (Foek et al., 2009). There was higher failure rate in maxillary arch and detachment of the retainer was the major cause of failure. Ardeschna (2011) has described 3 types of bond failures in fibre-reinforced plastic (FRPs) retainers.

- 1- Early failure: Adhesive failure at the enamel-bonding composite interface. In these instances, the enamel surface appeared clean.
- 2- Late failure: Adhesive failure between the FRP retainer surface and the bonding composite. In these instances, residual cement was left on the enamel surface. It is likely that this failure mechanism was accelerated by the wear and attrition of the bonding composite. A thickness of 1.0 mm of adhesive overlap has been suggested as optimum.
- 3- Third mechanism of detachment was **cohesive separation** of the FRP near the bonded surface, probably due to swelling of the matrix by the methylmethacrylate monomer. In this case, exposed fibers were observed at the surface of the FRC failure site.

Periodontal Implications

A few studies are present evaluating the periodontal and oral hygiene status of fiber-reinforced lingual retainers. Tackenet al.

(2002) in a 2-year prospective study concluded that patients in the glass fibre retainer groups showed significantly more gingival inflammation than those in the multistranded retainer groups. An in-vitro study done by Armando et al. (2012) demonstrated that with regard to chemical properties, the glass fibers were attacked by acids potentially present in the oral cavity, affecting the mechanical properties of the fiber. Thus this study concluded that in order to preserve the fibre bundle in the long-term, post-orthodontical oral hygiene is important. Oshaghet al. (2014) did animal study to evaluate the histological impacts of retainers in rabbits. The study concluded that FRC could cause detrimental effects on periodontal ligament and supporting bone whereas the 0.014 inch stainless steels (SS) and the 0.175 inch multistranded SS fixed retainers caused hyalinization and possibly the necrosis of the pulp. Similar finding was observed by the authors in a patient who reported to our Department with a broken steel wire retainer. He was subsequently bonded with a glass fibre retainer (DentaPreg*) and followed after 7 months. Visible stains and plaque was detected in the interdental and gingival areas of lingual surfaces of lower anterior teeth. However no considerable abrasion of surface composite was found. (**Figure 2 a,b,c**) (*Dentapreg Splint manufactured by ADM; Brno, Czech Republic)

Conclusion

Bonded fiber reinforced lingual retainers cannot be presently considered as "4th generation or future choice of retainer material. Despite being more esthetic, biocompatible and better retentive strength, the glass fiber retainers are more technique sensitive, expensive and have questionable clinical effectiveness. The multistranded or twisted stainless steel and other wire retainers still are most commonly and widely used. This paper has reviewed FRCs used as orthodontic retainers, in terms of bond strength, failure rates and periodontal status. The use of GFR retainers as a retention strategy should not be discouraged and the authors recommend further long-term investigations to confirm these findings.

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