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RESEARCH ARTICLE

COMPARISON OF FLEXIBILITY OF DIFFERENT SPLINT SYSTEMS USED IN DENTAL TRAUMA: AN IN-VITRO STUDY

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ABSTRACT

Background: Prognosis of a traumatised tooth is primarily dependant on the integrity of the PDL which can be ensured by stabilization of the luxated tooth. Flexible splints provide both physiologic tooth movement and stabilization as required for a good prognosis.
Aim: To evaluate flexibility of four splint systems – Group I-GC Everstick NET splint, Group II - Resin splint, Group III -Wire-composite splint and Group IV -Rectangular stainless steel arch wire.
Design: Maxillary resin casts were used where all the teeth were fixed apart from Maxillary right central incisors which were inserted in a non-rigid fashion so as to simulate luxated tooth. To simulate the form and characteristics of the periodontal ligament, polyvinyl siloxane was placed at apical level and around the root of Maxillary right central incisor. The load was applied and two stress analysis test (0 and 50 N directed longitudinally and 45 N directed obliquely) were performed using a universal testing machine. The stress required to displace and linear displacement were evaluated.
Results: Maximum displacement seen with wire composite group while everstick group shows the slightly ideal displacement which is required for healing of traumatized teeth.
Conclusion: Stainless Steel splint should be replaced with everstick splint as high aesthetics can be achieved which is prime concern in pediatric patients.

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INTRODUCTION

Semi rigid or Flexible splints provide both physiologic tooth movement and stabilization as required for a good prognosis. It has been observed that teeth stabilized with high flexibility splints are less likely to undergo root resorption and show a better reorganization of the periodontal fibres compared with teeth splinted by means of rigid contention devices (Andreasen *et al*., 2007). To optimise tissue healing during splinting there are two biomechanical factors that appear as the priority. First, the healing tooth-periodontal ligament (PDL)–bone interface should experience strains within the 'physiologic limit' (100– 1500 μm) and secondly, promotion of the healing interface should be achieved by 'controlling' micro movement of the tooth (approximately 50 μm) in the traumatized socket (Cengiz *et al*., 2006). Micro tension across a healing wound promotes production and maturation of collagen through the polymerization of fibrils, and may enhance the synthesis of precollege in fibroblasts (Enwemeka *et al*., 1991). Moreover, appropriate micro movement maintains sufficient blood circulation and venous return in the healing ligament (Yasuda *et al*., 2000) or encourages revascularization; accelerating the rate of periodontal reorganization and reattachment. Contrarily, complete immobilization prevents healing due to stress deprivation which may change the fibroblasts from an anabolic to a catabolic state, reducing collagen mass (Amiel *et al*., 1990). Semi-rigid splinting has, therefore, been a common method for controlled passive mobilization of the traumatized tooth in various displacements and root fracture injuries. There are several type of semi – rigid splinting techniques including wire-composite splint (Ebeleseder *et al*., 1995), bonded Kevlar or fiberglass splint (Ribbond) , button-bracket splint (Filippi *et al*., 2002), which has been described and investigated in the literature. Recently new contention system, that is GC Everstick NET splint (CC India Dental Pvt Ltd) that can satisfy the ideal requisites: appearance, user-friendliness and easy hygiene procedures, together with the ability to stabilize the traumatized tooth without employing an excessively rigid system. Pre impregated Everstick glass fibre splint are gaining more popularity due to their minimal invasiveness, reliable bonding, optimal handling properties and esthetics. This utilizes silanated E-type glass fibres embedded in a BISGMA matrix and surrounded by PMMA coating (interpenetrating polymer network) with good flexure strength of 1280 Mpa, having thickness of 0.1 mm (GC India dental). The majority of studies have aimed at measuring residual mobility to indicate the time at which the splints should be

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remained without the risk of teeth still being excessive mobile rather than evaluating the actual physiological movement under axial and oblique forces. Thus the study aims at compairing the flexibility of four different splints (GC Everstick splint, Resin splint, Wire-composite splint and Rectangular stainless steel arch wire) commonly used in clinical practice through in vitro assessment of their degree of rigidity, expressed by the tooth movement allowed by the various splints at both axial and oblique loads.

MATERIALS AND METHODS

Four different splinting methods were evaluated with five in vitro models in each group resulting in total of 20 splints. The protocol proposed by Oikarinen *et al*., was used to standardize in vitro models (Oikarinen. 1988). Maxillary resin cast of the upper arch were prepared, where Permanent maxillary right central incisor (used for the stress analysis) were inserted in a non-rigid fashion (to simulate the luxated tooth) whereas the other teeth (from canine of first quadrant to the canine of the second quadrant) were permanently fixed to the corresponding sockets.

To simulate the form and characteristics of the PDL, polyvinyl siloxane gel (Dow corning, MIL-A-46146 RTV coating) were placed at the apical level (thickness 3 mm to allow a small vertical movement and around the root (thickness 0.3 mm) of Permanent maxillary right central incisor.

The following groups were evaluated:

- Group I- GC Everstick NET splint (CC India Dental Pvt Ltd)
- Group II - Resin splint (RS)
- Group III- Wire-composite splint (WCS)
- Group IV- Rectangular Stainless steel Wire (RSS)

Before splint placement, the buccal aspect of the teeth was roughened with pumice powder and primer agent. For all the groups the extent of the splints was on the middle third of labial surfaces from Permanent maxillary right canine to Permanent maxillary left canine. For group I fibre (Bi-directional fibre mesh, Thickness – 0.1 mm) was placed with the help of flowable composite (Restofill flor nanohybrid flowable light cure composite). For group II composite was applied at the middle third of the interproximal surfaces. For group III double twisted stainless steel soft wire (26 gauge) was adapted and fixed by means of a conventional composite. For group IV rectangular stainless steel arch wire (Size-0.16" X 022") was placed by means of conventional composite (3M ESPE filltek Z250 X T). To assess the Flexibility, a stress analysis was performed using a universal testing machine. The machine, by means of a cylindrical punch which applied an increasing linear force (0-50 N).Using programmable logic controller (PLC) software, for each test, the machine elaborated a force movement graph that made it possible to evaluate the movement of the tooth when the applied load was increased. Axial load with linear increasing intensity of force ranging from 0 to 50 N was applied at the incisal margin of Permanent maxillary right central incisor and Oblique force at an angle of 45 degree. The two tests were done on twenty separate cast of four different splint. The increasing load of 0–50 N was chosen because these values fall into the physiological range of the masticatory forces, which amount to 10–20 N for soft foods and reach 100 N for harder ones (Weisman 1984).

RESULTS

Under vertical loading of different loads of 30N and 50N, the everstick showed least movement and the maximum movement was permitted by stainless steel wire (Table 1). Furthermore, everstick showed the least movement on oblique loading at 45 degree with varying forces (30N and 50N) and the maximum movement was observed with Wire Composite (Table 2). On comparing same splint using unpaired t test, there was significant difference found in the displacement brought about all the splints at 30N and 50N under both axial and oblique loads. Group I and IV showed displacement (mm) of tooth closest to confines of permissible physiological tooth movement at both 30N and 50N of axial load. Group II and group III showed more displacement than I and IV where group III was much beyond permissible physiological tooth movement. There was significant difference found in displacement at 30N and 50 N for same splint (Table 1& 2).

Table 1. Comparison of displacement of tooth (in mm) at 30 N and 50 N load in axial direction in different splints

Splints	Displacement (Mean ± SD, mm)		Unpaired t-test value	P value
	30 N	50 N		
Everstick (n=5)	0.044 ± 0.001	0.074 ± 0.001	47.43	0.000 (<0.05), Sig. diff
Resin Splint (n=5)	0.053 ± 0.001	0.088 ± 0.001	55.34	0.000 (<0.05), Sig. diff
Wire Composite(n=5)	0.530 ± 0.001	0.890 ± 0.001	569.21	0.000 (<0.05), Sig. diff
Stainless Steel wire (n=5)	0.094 ± 0.001	0.249 ± 0.001	245.076	0.000 (<0.05), Sig. diff

Test applied: Unpaired t-test, * $p < 0.05$ considered statistically significant

Table 2. Comparison of displacement of tooth (in mm) at 30 N and 50 N load in 45 degree obliquely in different splints

Splints	Displacement (Mean ± SD, mm)		Unpaired t-test value	P value
	30 N	50 N		
Everstick (n=5)	0.045 ± 0.001	0.075 ± 0.001	47.43	0.000 (<0.05), Sig. diff
Resin Splint(n=5)	0.087 ± 0.001	0.193 ± 0.001	167.60	0.000 (<0.05), Sig. diff
Wire Composite (n=5)	0.266 ± 0.001	0.426 ± 0.001	252.98	0.000 (<0.05), Sig. diff
Stainless Steel wire (n=5)	0.076 ± 0.001	0.152 ± 0.001	120.17	0.000 (<0.05), Sig. diff

Test applied: Unpaired t-test, * $p < 0.05$ considered statistically significant

DISCUSSION

According to the American Academy of Pediatric Dentistry (AAPD) the ideal requirement of splint include: easily fabrication in the mouth without additional trauma, should be

passive unless orthodontic forces are intended, should allow physiologic mobility, should be non irritating to soft tissues, should not interfere with occlusion, should allow endodontic access and vitality testing, should be easily cleansed and easily removed. The purpose of dental splinting is to stabilize the tooth for required time period so as to furthermore protect the attachment apparatus in order to allow the periodontal fibres to regenerate (Clinical guidelines AAPD). The duration of splinting should be as short as possible as the periodontal ligament reaches most of its normal strength 7-14days following trauma (Filippi *et al*., 2002). In present study the two different angles were taken for analysis to replicate the forces applied on the teeth in physiological condition as precisely as possible. The readings were also recorded at 30 N because according to Mazzoleni *et al*., for the Resin splint, it was impossible to calculate the relative movement at 50 N because it constantly fractured with smaller loads (Mazzoleni *et al*., 2010). Fixation of the 'traumatized' tooth was performed on three neighboring teeth, as extending a splint to more than one adjacent firm tooth has no beneficial effect. Ebeleseder *et al*., have shown in vitro that increased distance between a splinted tooth and its neighbors reduces the controlled immobilization effect of a semi-rigid splint. Nevertheless, with increasing length (moment arm), a splint allows more deformation with the same force, resulting in the decrease of the rigidity of free and deformable section of the splint. Every tissue including the hard and soft tissues surrounding natural teeth has a micro damage threshold (Ebeleseder *et al*., 1995). Andreasen *et al*., demonstrated teeth which lost their splints during the observation period healed better than teeth which had been fixe6d for four or six weeks and that one week is enough to ensure that a luxated tooth is clinically firm (Andreasen *et al*., 2004). Pre-impregnated everStick glass fibre splints are gaining more and more popularity due to their permissible flexibility, minimal invasiveness, reliable bonding, optimised handling properties and aesthetics. They offer a dynamic alternative for stabilizing traumatized teeth because ever Stick products have a unique, patented interpenetrating polymer network* structure (IPN) .This unique IPN feature ensures both micro mechanical and chemical bonding of everStick fibres to composites, adhesives or composite cements. Moreover the splint can be removed whenever required because of the Bi-directional fibre mesh form bonded into single fibre.

With the help of flexible splints semi-physiological mobility can be obtained. Although the wire composite is semi rigid splint but according to the results, wire composite showed the higher flexibility beyond the range of permitted physiologic mobility ranging upto for maximum of 150micromm in the alveolar socket. Wire Composite Splint seems to protect the traumatized teeth from stresses in the apical and cervical regions more than the other splint types because of the higher intrinsic rigidity of the orthodontic wire fixed on the tooth surface.As a result, one could draw the wrongful conclusion that the higher the splint rigidity, the better the chances of healing because of the lower stress exerted on the injured periodontal tissues (Szmukler-Moncler *et al*., 1998). Resin splint and stainless steel wire splint also showed some amount of displacement but less than the range which is required to promote the healing of traumatised teeth.Minimum displacement seen with everstick splint group as the value fall nearby to the limit which is necessary for healing of traumatised tooth. Also everstick fibre reinforcement are combination of glass fibres and polymer resin matrix which holds the individual glass fibres in a bundle or a sheet which makes it flexible. Although, everstick is boon to traumatized teeth, but everstick being used as routine procedure is slightly questionable as it is not cost effective and it entirely depends on patient acceptance. Another factor which has to be taken into consideration for further validating the results of present study is that the structure and the physical properties of photoelastic resins never simulate the complex nature of living bone, i.e., cell signaling processes, strain mediated fluid flow and so forth. Therefore, the results of this study are only descriptive and further in-vivo studies are required to substantiate the results of this study.

Conclusion

According to the current guidelines and within the limits of in vitro study, it can be stated that flexible or semi rigid splints such as everstick is appropriate for splinting teeth for the treatment of traumatic lesions involving supporting periodontal tissues of tooth because it allows the movement to promote healing of tissues and resemble physiological condition as closely as possible.

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