ORIGINAL RESEARCH

Shear Bond Strength of a Sand Blasted Dental Splint - An In Vitro Study

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ABSTRACT

Background / Aim: Traumatic Injuries to the dentition of the children are one of the common problems that a dentist encounters in clinical practice. Among these injuries, avulsion and displacement of teeth are common problems encountered in the primary and mixed dentitions. Dental splinting after such injuries is needed to stabilize subluxated, luxated and avulsed teeth.A strong bond between the wire and material used for splinting will help to retain the splint in position. Studies have been meagre on methods of enhancing the bond strength between stainless steel wires and the composite resins and RMGIC when used as dental splints. Thus, the aim of the present study was to evaluate the shear bond strengths of wire-composite and wire-RMGIC interface when used as dental splints after sand blasting the wire surface.**Methodology:** 40 therapeutically extracted permanent anterior teeth were collected. The collected teeth were randomly assigned to 4 groups and were mounted. Stainless steel wires were sand blasted (for Group III and Group IV) and were bonded to teeth allotted to the respective groups. The Composite resin and RMGIC were bonded to teeth and the amount of material used was standardized using split acrylic template. Each specimen was tested under Universal testing machine and the force to dislodge the wire was recorded. **Results:** The results were tabulated and statistically analyzed using One way ANOVA and Post-hoc TUKEY's test. **Conclusion:** Sand blasted stainless steel wire bonded to composite showed statistically significant results than a plain stainless steel wire bonded to composite and RMGIC.

KEYWORDS: Sand Blasting, Dental Splint, RMGIC, Composite

INTRODUCTION

Traumatic injuries to the dentition of children are one of the common problems that a dentist encounters in clinical practice. And it may create a great psychological impact on both the parent and the child to see the loss of a fragment of their teeth or to notice the mobility of the involved tooth after a traumatic injury.[1]

Of the various traumatic injuries, avulsion and displacement of teeth are the most commonly encountered problems in the primary as well as mixed dentition period. Dental splinting after traumatic tooth injury is necessary to stabilize subluxated, luxated, avulsed and root fractured tooth.[2] Rigid dental splinting which was based on the principles of bone fracture immobilization, has been the treatment of choice until the 1970s. However, experimental and clinical studies have shown that early restoration of the masticatory function improves pulpal and periodontal healing.[3]

Many of the splints used in today's practice are inadequate in a way that they seldom allow normal repositioning of the displaced tooth.[4] Flexible wire-composite splint offers optimal lateral support for the splinted tooth and vertical flexibility which has been experimentally known to improve periodontal healing of luxated tooth.[5,6] The bond strength of the wire to the cementing material used is an important factor in a successful splint. Most of the failures of this wire-cementing material combination splint occurs at the wire-cement interface.[3] So methods of increasing the bond strength of the wire-cement interface are very important for a successful dental splint. A strong bond between the wire and the cement will help to retain the splint in position for the required stabilization period.

The material other than composite resin which is most commonly used in dentistry is Glass Ionomer Cement.[7] Despite various advantages like adhesion to tooth structure, biocompatibility and esthetics, GIC has a unique property of being cariostatic due to its fluoride releasing ability, which inhibits caries not only on the restored teeth but also on the adjacent teeth. Another category of glass ionomers is the light-polymerized liquid resin component that renders the cement photocurable as part of the overall hardening reaction. These "resin-modified glass ionomer cements" have gained much interest and use in pediatric dentistry over the last decade. Fracture toughness, fracture resistance, and wear resistance are the improved properties that are seen in resin-modified glass ionomers (RMGIC).[8]

However, studies have been meagre on methods of enhancing the bond strength between stainless steel wires

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and the composite resins and stainless steel wires and RMGIC when used as dental splints.

This study was to evaluate and compare the wire-composite and wire-RMGIC interface bond strengths of dental splints after blasting the stainless steel wire.

The research hypothesis was, the shear bond strength of wire-composite resin and wire-RMGIC interface of dental splints will alter when the wires are Sand blasted.

MATERIALS AND METHODS

Study Setting: The present study was conducted in the Department of Pedodontics and Preventive Dentistry, Bapuji Dental College and Hospital, Davangere, in association with Department of Prosthodontics including Crowns and Bridge, Bapuji Dental College and Hospital, Davangere and Bapuji Institute of Engineering and Technology, Davangere, Karnataka.

Study Design: This is an experimental *in vitro* study, comparing between groups.

Groups:

Control Group:

- Application of composite to the Plain stainless steel wire. (Group I)

Experimental Groups:

A. Application of RMGIC to the Plain stainless steel wire. (Group II)
B. Application of Composite to the Sand Blasted stainless steel wire. (Group III)
C. Application of RMGIC to the Sand Blasted stainless steel wire. (Group IV)

Methodology: The study was conducted on forty extracted permanent teeth with sound crown structures remaining.

Teeth were mounted in acrylic using a split rectangular aluminium box consisted of two plates namely the upper and the lower plates and two side joints. On the lower plate, a line was marked to indicate the place where the tooth would be positioned. The tooth was then placed at the position marked on the lower plate. The labial surface of the tooth was positioned in such a way that the most prominent portion of the labial surface was in contact with the lower rectangular plate. The side joints were placed in their respective positions to form an open rectangular box (Fig.1). Self-cure acrylic powder was sprinkled on the tooth and monomer added drop by drop (sprinkle-on method). The whole rectangular box was filled with the acrylic using the same sprinkle-on method. The box was closed with the upper plate, tightened and placed in distilled water. After the polymerization reaction, the acrylic block with the tooth specimen was then separated from the rectangular metal box. The tooth surface was covered with adhesive tape except

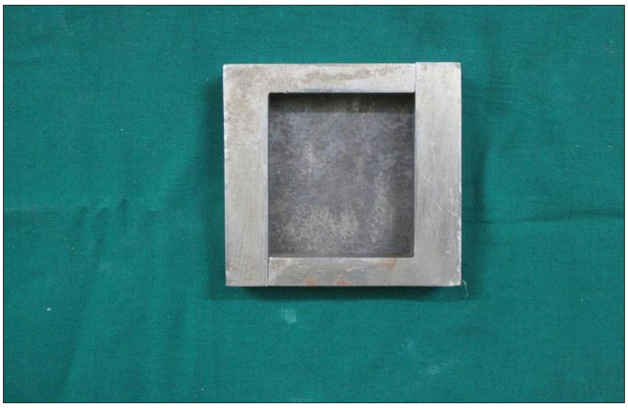


Fig 1

for bonding site of diameter 4.4mm. The stainless steel wire was prepared with a loop at one end of it (Fig.2).

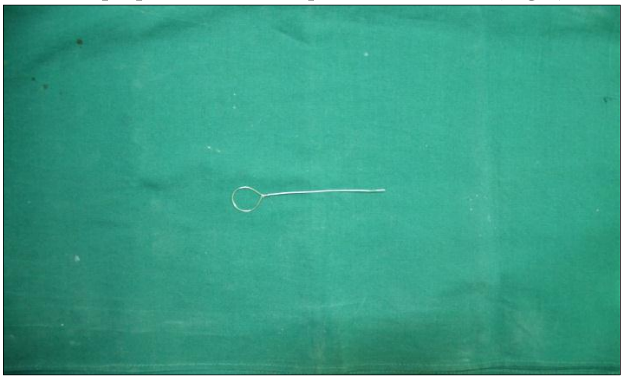


Fig 2

To standardize the amount of composite/RMGIC used for splinting, a standard acrylic template was devised. The acrylic template was a transparent split mould which could be separated after the bonding procedure. The template had a round well of 4.4mm diameter and 1.75mm depth with a uniform 15.2mm bonding surface area.

Sand Blasting The Stainless Steel Wires: Sand blasted groups together consisted of 20 stainless steel wires. 0.016" stainless steel wires (H.P INDUSTRIES, CALICUT, INDIA) were sandblasted with 50 microns aluminium oxide at a pressure of 75 psi for 15 seconds (Fig.3).

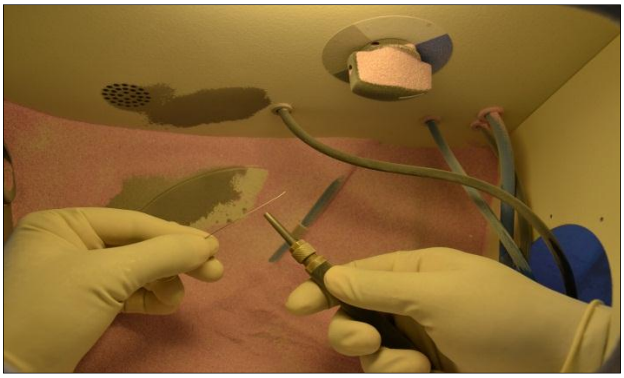


Fig 3

The sand blasted stainless steel wires were bonded to the labial surfaces of teeth with composite (FILTEK Z350, 3M ESPE, INDIA) (Group III) and RMGIC (KETAC N 100, 3M ESPE, INDIA) (Group IV) as per their manufacturers' instructions according to the group to which they were assigned to and light cured (Fig.4).

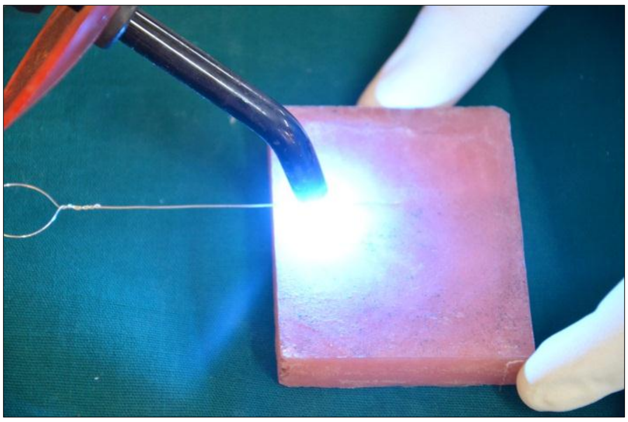


Fig 4

The plain stainless steel wires were bonded to the labial surfaces of teeth with composite (Group I) and RMGIC (Group II) as per their manufacturers' instructions according to the group to which they were assigned to and light cured.

The samples were then thermo cycled between 4°C and 60°C for 100 cycles with a dwell time in each thermal bath of 1 minute to further stress the wire-composite and wire-RMGIC joint.

The samples were tested using a Universal Testing Machine (HOUNSFIELD) at a crosshead speed of 1mm per minute. The maximum force needed to dislodge the wire was recorded (Fig.5).

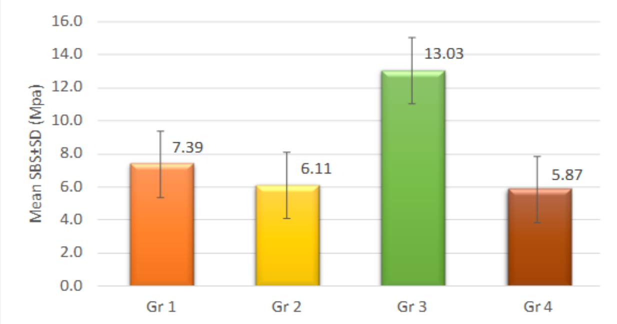
Fig 5

The results thus obtained were subjected to statistical analysis.

Statistical Analysis: The results were expressed as Mean ± SD. For the evaluation of shear bond strength, multiple group comparison was made using One-way Analysis of Variance (ANOVA) complemented by Tukey's post-hoc test.

RESULTS

The mean shear bond strengths and standard deviations between the control group and experimental groups are shown in Graph 1 and Table 1.



Graph 1: Represents the mean bond strength in Mpa and standard deviations between the Control and Experimental Groups.

GROUPS		SHEAR BOND STRENGTH (Mpa)			
		Mean	SD	Range	
1 (Control)	Composite with plain stainless steel wire	7.39	3.70	3.12	12.75
2 (Experimental)	RMGIC with plain stainless steel wire	6.11	2.28	3.30	9.68
3 (Experimental)	Composite with sand blasted stainless steel wire	13.03	1.90	8.59	15.08
4 (Experimental)	RMGIC with sand blasted stainless steel wire	5.87	3.22	1.80	10.52
One Way ANOVA		F = 13.72, P < 0.001, HS			

TABLE 1: Descriptive statistics of the inter group comparison of the mean and standard deviation of shear bond strength values of the control and the experimental groups.

Group III showed the highest shear bond strength than other three groups. On intergroup comparison the difference found was statistically highly significant (p<0.001).

DISCUSSION

Injuries to primary and permanent teeth and to the supporting structures are commonly encountered in dental practice. Traumatic injuries may involve crown fractures, root fractures, crown-root fractures, dentoalveolar injuries like luxation and avulsion, severe maxillofacial trauma involving the bony structures or a combination of the above. Management of these injuries would be a challenge to any practicing pediatric dentist.

Dentoalveolar injuries like luxation and avulsion require splinting for stabilization of the displaced teeth. It is nowadays widely accepted that the treatment of bony fractures and tooth luxations should be in principle kept separate because, studies have shown that absolute fixation to attain bony union as well as tooth fixation could lead to harmful complications.[9] Instead, early reconstruction of normal vertical movement improves and accelerates the healing of periodontally injured teeth. The splint should, therefore allow slight flexibility.[4]

Splints that have been commonly used for dentoalveotar injuries are Arch bar splints (arch bar ligated to teeth with soft stainless steel wires), Orthodontic band acrylic splints (orthodontic band cemented on teeth and cold cure acrylic added on bands to unite the teeth), Schurdart splints (half round aluminium brass alloy bar ligated to teeth with soft stainless steel wires and then covered with acrylic)[6,10,11]. Recently, Fermit splints (made up of light cured composite applied on teeth and cured), Kevlar splints (two Kevlar threads moistened with resin and fixed on teeth), Wire-composite splints (flexible wire fixed on teeth with composite resin) have been tried in several clinical studies.[4,12,13]

Studies have shown that the flexible wire-composite splint allowed adequate lateral support for the splinted teeth and maintained vertical flexibility which has been experimentally known to improve periodontal healing of luxated or avulsed teeth.[4] Most of the other splints are unable to maintain adequate vertical or horizontal flexibility and so cannot be considered as ideal splinting techniques. Hence, wire-composite splint, was chosen as the control group for the present study.

The wire-composite splint meets most of the demands of a tooth fixation. For the success of the wire-composite splint both the wire and the composite resin play a critical role. The interface between the wire and the composite resin has been the weakest joint in this splint. The methods of increasing the bond strength between the wire and the composite resin would greatly enhance this weak bonding at the interface thereby increasing its clinical success rate. Hence, this study was aimed to evaluate the optimal method of enhancing the bond strength of the wire-composite interface of the dental splints using different wire surface treatments.

Thin flexible wires have been recommended for the wire-composite splint. Flexible wires allow normal physiologic mobility and thereby improve periodontal healing. Further, these wires have to remain passive as even minor forces (0.2N) may cause tipping movement on teeth.[5]

Various methods have been employed to increase the bond strengths between the metal and resin. Such as, mechanical retention methods like undercuts and roughening of the metal surface, micro retention methods like sandblasting, electrolytic etching and tin-plating.[14,15,16]

Mechanical methods of roughening have inherent disadvantages that it might weaken the wire, and a uniform roughening pattern may be difficult to achieve. Further, electrolytic etching technique is alloy specific, technique sensitive and requires the handling and storage of potentially harmful acids.[14] Tinplating requires the use of specialized equipment, is technique sensitive and cannot be used intra-orally as the plating solution may cause injury if ingested or if it comes in contact with the eye.[15]

Sandblasting can be carried out either at the chair side or in the laboratory. It is less technique sensitive and requires no sophisticated equipment.[15] Hence, in the present study, Sandblasting, was included as the intervention of choice for enhancing the bond strength of the wire-composite interface and wire-RMGIC interface.

With light cured composite material, Sandblasting of the 0.016" round S.S. wire resulted in higher wire-composite interface bond strength (13.03MPa) when compared to Non surface treated plain stainless steel wires (7.39MPa). This adds evidence to the view that micro-mechanical retention of Sandblasting enhances the wire-composite bond strength even though they were of lesser dimensions. Oesterie (2001) also reported similar wire-composite interface bond strengths for Sandblasted wires (16.1MPa), which were statistically higher than Control wires (1.1MPa).[17]

With RMGIC material, Sandblasting of the 0.016" round S.S. wire resulted in decreasing the wire-RMGIC interface bond strength (5.87MPa) when compared to Non surface treated plain stainless steel wires (6.11MPa).

These findings can be explained with the reference of a study done by Burrow et al. who had stated that with RMGIC, most of the failures occurred due to cohesive failure. He postulated that RMGIC itself contained many air inclusions which acted as stress bearing points. These voids further got accentuated with the roughened sandblasted wire surfaces.

With the 0.016" S.S. wire, Light cured composite had significantly higher bond strength than RMGIC ($p<0.001$) as shown by the one way ANOVA. Further, Post-hoc Tukey’s test revealed that between sand blast and plain stainless steel wires, the former showed a higher bond strength with composite than RMGIC. This might be attributed to the superior mechanical properties of light cured composites, particularly tensile strength and fracture toughness.[18] This is also in accordance with the previous Scanning Electron Micrograph studies which had revealed that sandblasting itself would provide excellent micromechanical retention due to the presence of a large number of undercuts and irregularities on the wire surface.[19]

SCOPE FOR FUTURISTIC INTERVENTIONS

In the present study, every effort was made to simulate the oral conditions but however, the *in vivo* responses of the wire-composite and wire-RMGIC dental splints may differ from the results of this *in vitro* study. Nonetheless, clinical implications of this research are significant. The conclusion of this *in vitro* investigation must be extrapolated to the clinical situation with care, and further *in vivo* trials are needed to confirm the validity of these recommendations.

CONCLUSION

The present study was conducted to evaluate and compare the wire- Composite and wire- RMGIC interface bond strengths of dental splints after blasting the stainless steel wire. Composite resin showed higher shear bond strength with Sandblasted stainless steel wires than RMGIC. Sandblasted stainless steel wires showed higher shear bond strength than plain stainless steel wires when bonded to composite resin and RMGIC. Within the limitations of the present study, a composite material with a sand blast stainless steel wire can be recommended for the fabrication of dental splints.

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