Class IV preparations for fractured anterior teeth restored with composite resin restorations

Hani Eid* / George E. White**

Pediatric dentists play a major role in treating most of the anterior teeth fractures due to the fact that most patients who suffer such traumatic injuries are between the ages of seven and fourteen. Several techniques has been developed to restore the fractured incisors to the original shape and color, these include full-coverage of the traumatized tooth, or restoring the incisors with a resin. The purpose of this study is to find the ideal combination of tooth preparation and restorative material, namely, to determine if stair step chamfer preparations provide more retention in class IV restorations than the plain chamfer preparation technique when restored with a combination of a hybrid composite resin and a microfilled composite resin. This was done by comparing the shear strength values between the buccal stair-step chamfer preparation, and a modification on it (buccal and lingual stair-step chamfer preparation) and the plain chamfer preparation techniques in class IV restorations on anterior incisors using different composite resin materials. The Instron machine was used to test shear strength.

One hundred and two bovine incisor teeth were freshly harvested from the slaughterhouse. The teeth were prepared and restored according to the following six groups; Plain Chamfer preparation with Tetric Ceram Composite, Plain Chamfer preparation with Renamel Composite, buccal stair-step chamfer preparation with Tetric Ceram composite, buccal stair-step chamfer preparation with Renamel composite, Buccal and lingual stair-step preparation with Tetric Ceram Composite, Buccal and lingual stair-step chamfer preparation with renamel composite. All samples were fractured using the Instron testing machine then the surface area were measured using Image-J software. Shear strength for every sample was calculated using the load numeric result from the Instron machine and the measured surface area.

The Two-Factorial (AB) Analysis of Variance For Independent Samples showed that the buccal stair-step chamfer preparation showed significantly higher shear strength and fracture resistance than plain chamfer or the buccal and lingual stair-step chamfer preparation. The combination of Renamel Hybrid and Renamel Microfill composite materials showed better results than the Tetric Ceram composite when used with all three preparation techniques, but did not show a statistical significance.

It was concluded that buccal stair-step preparation technique provided the ideal preparation technique with bonded composite resins in fractured anterior teeth. Only 7% of the entire sample size had an adhesion failure versus 93% that had cohesion failure. There was no significant difference in shear strength, between the restorative materials used, in conjunction with all the preparation techniques.
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INTRODUCTION

Pediatric dentists have a major role in treating most of the anterior teeth fractures due to the fact that most patients who suffer such traumatic injuries are between the ages of seven and fourteen.[3]

Davis,[17] in a study of 2,237 students seven through seventeen years of age reported a prevalence of 22.8 percent. Ulfohn,[73] reported that 89% of the fractures happen in the maxilla. The tooth most affected by fracture is the maxillary central incisor at 75%.

In recent years it became possible to solve this problem with minimum discomfort to the child in a one short visit, without the need for local anesthesia. When restoring such fractures esthetics and retention are the

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major criteria that dentists strive to achieve for the ideal restoration.

Several techniques has been developed to restore the fractured incisors to the original shape and color, these include full-coverage of the traumatized tooth, or restoring the incisors with a composite.

Full coverage

Full-crown coverage started with the adaptation of a preformed stainless steel crowns,[3,12,19] which implied significant esthetic problems even if the design was modified using various window preparations or tooth colored facings of the steel crowns.[2]

Acrylic crowns, although they had better appearance than stainless steel crowns, posed a different problem where longevity and color stability in the oral environment caused most of the failures and patients lack of acceptance.[47]

Porcelain fused to metal crowns and porcelain crowns offered the practitioner and the patient a long-term solution that is esthetically pleasing.[40,44] However full-coverage crowns necessitate excessive removal of sound tooth structure, it is also time consuming and expensive. Furthermore they are contraindicated in the adolescent due to the large pulp chamber and the accentuated pulp response to the combined effect of trauma and excessive preparation.[19] Another consideration is that in most cases the teeth in young children are not fully erupted and that would complicate the positioning of the full-crown margin beneath the free gingival crest causing a less desirable result when eruption is complete.[16,19]

Composite resins

Introduction of the acid etch technique by Buonocore in 1955 revolutionized aesthetic dentistry.[12] This technique was then applied to the restoration of fractured anterior teeth providing retention without gross removal of tooth structure.[12,14]

To gain the best retention, durability, and esthetics qualities practitioners and researchers varied the restoring materials, bonding agents, and preparation designs.[8,45,60]

Materials evolved from acrylic resins to composite resins that varied in the filler particle size and amount.[29,35] In the past clinicians were reluctant to use resins in larger anterior teeth buildups due to the poor physical characteristics. The resins lacked color stability, wear resistance, polishability, and sculptability.[5] Today, the physical properties of composite resins have reached a high level of excellence.[23,38,41,53,54] The newer formulations of particle size and distribution have imparted higher strength and varying degrees of polishability allowing the use of composite resins in high stress bearing areas and concomitantly providing a level of polishability that rivals that of glazed porcelain and close to dental enamel.[26,42,57]

Opinions varied between authors on materials to be used when restoring anterior teeth fractures. The ideal material should withstand occlusion forces and be fracture and wear resistant, it should also provide excellent esthetics matching the original tooth structure.[45,72,75]

Macrofilled and hybrid composites proved to be more wear and fracture resistant,[76] microfilled composite materials have nice polishability luster and surface smoothness providing enhanced esthetic results, but they lack the strength that the hybrid provides.[51,69,71]

Some authors suggested a combination between the strong hybrids and the esthetic microfill composite materials to have a homogenous wear resistant esthetic restoration.[27,77]

Recent hybrids have filler particle over 80% giving them increased resistance to fracture or wear.[51,54]

Bonding agents

Retention of resin restorations relied for the most part on the effectiveness and the durability of the bonding system that is being utilized. A recent article by Kugel and Ferrari[51] summarized all generations of bonding agents and the evolution of these agents. There was great advances from the first generation when Buonocore introduced his acid-etch technique to the 4th generation where the smear layer was completely removed thus enhancing the effect of bonding agents,[68] to the most recent generations with the one bottle system giving much improved retention results.[5,34,67]

Preparation designs

Preparation techniques have also varied overtime to adapt to the different types of materials, which were in use. Various enamel preparation techniques have been recommended. These were:

No preparation just conditioning the enamel with pumice then acid-etch.[7,13,56,59,66,71,72] Mainly these authors recommended no tooth preparations to prevent further trauma to a recently injured tooth and to preserve sound tooth structure. But several researchers showed later the weakness of this technique. Fahl *et al*.[27-30] in numerous publications concluded that such an approach is hazardous for several reasons. First unprepared enamel surfaces may be highly resistant to acid conditioning because of the presence of fluoresced and prismless superficial layer of enamel. Second, this technique almost always results in an over contoured restoration that may be esthetically objectionable. In addition it is extremely difficult to finish the restoration to a non-existent or an ill-fitted margin outline.

Pin retained restorations[19,37] Pins were mainly used to increase retention of composite restorations. It was proved in a clinical trial that pins didn't make a significant difference in retention than other preparation techniques.[6,46]

Also some of the observed disadvantages were mentioned like discoloration due to corrosion, increasing

the stress in the dentin or crazing of dental enamel causing microleakage and subsequent discoloration and pulp irritation.[33]

Butt joint[13,52,55] was mainly used to have a proper line that the restoration could be finished to. Several articles comparing this technique with the bevel technique found the bevel to be significantly more retentive.[8,11]

Bevel preparation technique[4,8,9,11,15,25-31,36,39,40,48,61,64,65,69,71,73,74,77] Various authors described different bevel preparation techniques. Black recommended a 45-degree bevel extending 2 mm beyond the fractured incisal edge and through the entire enamel thickness. This method provided better retention of the restoration than a butt joint and better accessible cavosurface angles.[11,15,61] A lot of researchers and authors suggested increasing the length of the bevel towards the cementoenamel junction, providing by this method more surface area to bond to, also hiding the finish line high below lip line.[26-31,39,40,58,64,65,74] Bagaheri and Denehy found in an *in vitro* experiment that increasing the length of the bevel beyond 1 mm did not have any significant difference on retention.[8] However they found that thickness of the bevel had a significant effect on retention of the composite restoration.[9]

Armstrong,[4] advocated the bevel for several reasons including its ease of operation, conservative tooth preparation, reduced additional insult to recently traumatized teeth.

Chamfer preparation design[10,17,18,20-22,45-47,66] By increasing the thickness of the bevel a margin similar to the chamfer preparation technique would be achieved. In 1977 Jordan *et al*,[47] introduced the chamfer preparation as a method to prepare hypoplastic or fractured anterior teeth in order to restore them with composite resins. Various authors,[10,17,18,20-22,45-47,66] adopted this preparation technique. The circumferential chamfer preparation technique, allows the effective removal of the superficial layer of enamel exposing the more reactive subsurface enamel to the effect of acid etching. It also enhances the effect of acid-etching by ensuring that the ends of enamel prisms rather than the longitudinal axes are exposed to the effects of acid. It also provides a well-defined marginal periphery to which the composite is easily finished in addition to the added thickness of the marginal bulk of the restorative material increasing the fracture, and leakage resistance, which essentially eliminates the white line margin.

Later, other investigators compared chamfer and bevel preparations for retention and they found that chamfered preparations provided greater restoration fracture resistance and higher retention to tooth structures.[18,20-22]

Later several practitioners modified the chamfer preparation by scalloping the straight finish line to gain more surface to bond to, thus increasing retention.[43,55,62]

In a similar preparation technique, Albers in 1996 introduced the stair step chamfer preparation for class IV restorations. He describes this preparation design as a chamfer that follows the vertical and horizontal anatomical contours, making the preparation look like stair steps. This preparation showed good esthetic results because the chamfer margins and the vertical contours between the lobes overlap making it hard to locate the chamfer margins.[1]

Pilot Project

In a pilot project that was published recently[24] three groups were compared, the bevel preparation, plain chamfer preparation, and the stair-step chamfer preparation for retention of bonded composite restorations. It was found that the stair step chamfer preparation provided higher shear strength resistance than the bevel or the plain chamfer preparations but not to a significant difference (Figure 1).

It was also found that most of the tested restorations in the stair-step chamfer preparation group fractured under the Instron machine within the composite, in contrast to the bevel or the chamfer preparations where the fracture happened on the interface between the restoring material and tooth structure.[24] This supports the conclusion that adhesion was sufficient with the stair step chamfer preparation, but the cohesion quality of the restoring material needs improvement to approximate natural tooth resistance to fracture.[20,38]

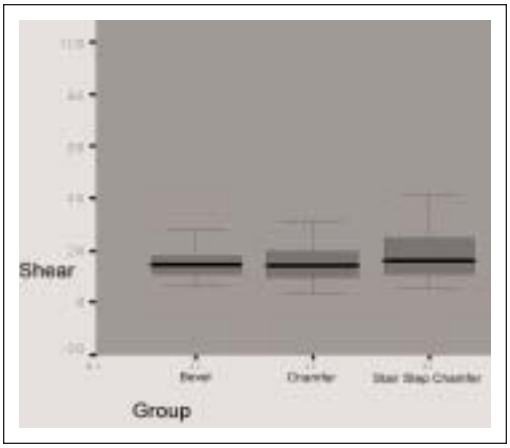


Figure 1. Mean shear strength comparison between the bevel, chamfer, and stair-step chamfer.

Many investigators used various tooth preparations and restorative materials, to create the ideal restoration that resembles tooth structure and color. However we continue to have no distinct guidelines for restoring class IV fractures with resin composites.

The purpose of this study is to find the ideal combination of tooth preparation and restoring material. This will be done by comparing the shear strength values between the buccal stair-step chamfer preparation, and

a modification on it (Buccal and lingual stair-step chamfer preparation) and the plain chamfer preparation techniques in class IV restorations on anterior incisors using different composite resin materials.

MATERIALS AND METHODS

Tooth material

One hundred and two bovine incisor teeth were freshly harvested from the slaughterhouse. All teeth were within 1mm difference in the mesio-distal crown width. The teeth were cleaned of soft tissues and washed thoroughly with tap water, then were Frozen at -20˚ C to maintain "freshness" during storage.[70]

Each tooth was mounted in a 0.5inch diameter cylinder of acrylic resin and numbered. The teeth were then polished with pumice using a soft rubber cup in a slow speed hand piece. The teeth were all divided equally and randomly into 6 groups as shown in Table I.

A standardized mesial fracture was created incisally as drawn in Figure 2. The fracture was simulated using a no.48 XF diamond bur, in a high-speed hand piece, with water coolant. All preparations will be made with a fine diamond bur (No. 48 XF), using a high-speed hand piece with water coolant.

Groups and preparation technique

The teeth were prepared and restored according to the following groups:

Group I. Chamfer preparation (Figure 3) with single composite: it has a plain chamfer shoulder preparation around the entire enamel periphery and extends cervically approximately 2 mm beyond the edge of the fractured enamel and involves half of the enamel thickness in depth. This group will be restored with Tetric Ceram composite (Ivoclar-Vivadent, Amherst, NY).

Group II. Buccal stair-step chamfer preparation (Figure 4) with single composite: it has 2 mm width, and 1 mm depth chamfer into the enamel around the cavosurface margins, while doing stair steps that follow the anatomical vertical and horizontal lines of contour on the buccal surface of the incisors. This group will be restored with Tetric Ceram composite (Ivoclar-Vivadent, Amherst, NY).

Group III. Buccal and lingual stair-step preparation (Figure 5) with single composite: it has 1 mm depth, and 2 mm width chamfer into the enamel around the cavosurface margins, while doing stair steps that follow the anatomical vertical and horizontal lines of contour on the facial of the front teeth and matching stair-steps on the lingual surface of the incisors. This group will be restored with Tetric Ceram composite (Ivoclar-Vivadent, Amherst, NY).

Group IV. Chamfer preparation with a composite combination: it has a plain chamfer shoulder preparation around the entire enamel periphery and extends cervically approximately 2 mm beyond the edge of the fractured enamel and involves half of the enamel thickness in depth. This group will be restored with a combination of Microfill composite (Renamel[tm] Microfill) and a Hybrid composite (Renamel[tm] Universal Hybrid)

Group V. Facial stair-step chamfer preparation with a composite combination: it has 1 mm depth, and 2 mm width chamfer into the enamel around the cavosurface margins, while doing stair steps that follow the anatomical vertical and horizontal lines of contour on the facial of the front teeth. This group will be restored with a combination of Microfill composite (Renamel[tm] Microfill) and a Hybrid composite (Renamel[tm] Universal Hybrid).

Group VI. Facial and lingual stair-step preparation with a composite combination: it has 1 mm depth, and 2 mm width chamfer into the enamel around the cavosurface margins, while doing stair steps that follow the anatomical vertical and horizontal lines of contour on the facial of the front teeth and matching stair-steps on the lingual for added retention. This group will be restored with a combination of Microfill composite (Renamel[tm] Microfill) and a Hybrid composite (Renamel[tm] Universal Hybrid).

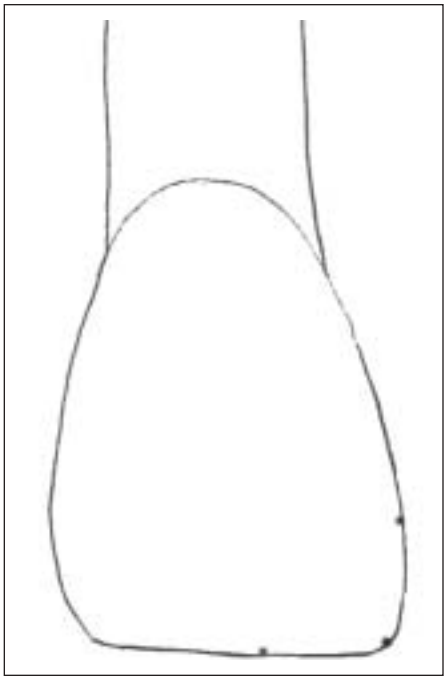
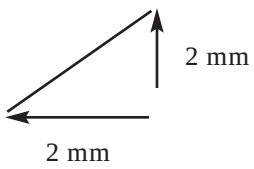


Figure 2. Simulation of the mesial fracture



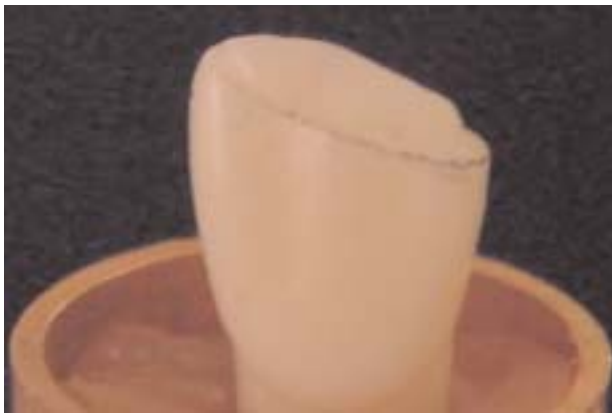


Figure 3. Plain Chamfer

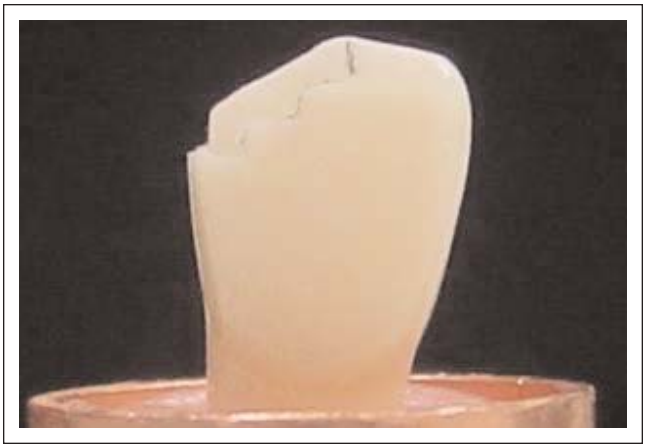


Figure 4. Buccal Stair step Chamfer

Table I. The Six Groups

Group number	Type of preparation and restoration
Group I	Plain chamfer Preparation with Tetric Ceram Composite (Ivoclar- Vivadent, Amherst, NY)
Group II	Stair-step chamfer Preparation with Tetric Ceram Composite(Ivoclar- Vivadent, Amherst, NY)
Group III	Stair-step chamfer preparation on both facial and lingual with Tetric Ceram composite(Ivoclar- Vivadent, Amherst, NY)
Same preparations with different materials:	
Group IV	Plain chamfer Preparation with a combination of Microfill composite (Renamel[tm] Microfill) and a Hybrid composite (Renamel[tm] Universal Hybrid)
Group V	Stair-step chamfer Preparation with a combination of Microfill composite (Renamel[tm] Microfill) and a Hybrid composite (Renamel[tm] Universal Hybrid)
Group VI	Stair-step chamfer preparation on both facial and lingual with a combination of Microfill composite (Renamel[tm] Microfill) and a Hybrid composite (Renamel[tm] Universal Hybrid)

Table II. Distribution of samples between the groups.

Material	Preparation Technique		
	Plain Chamfer Preparation	**Buccal Stair Step Chamfer Preparation**	**Buccal and Lingual Stair-Step Chamfer Preparation**
Tetric Ceram	Group 1 (17 Samples)	Group 2 (17 Samples)	Group 3 (17 Samples)
Renamel	Group 4 (17 Samples)	Group 5 (17 Samples)	Group 6 (17 Samples)

Figure 5. Buccal and Lingual Stair-Step Chamfer

Restoration technique

All teeth were restored according to the following criteria; the enamel margins were acid-etched with 35% phosphoric acid gel (Ultra Etch, Ultradent) for 20 seconds and the dentin for 10 seconds, and then thoroughly rinsed with water. To keep the dentine surface moist, a damp cotton pellet were placed on the dentin surface and removed just before bonding. A fifth generation bonding agent (Excite Ivoclar- Vivadent, Amherst, NY) were placed and polymerized for 20 seconds using a 3000 Curing Light (3M).

Groups I, II and III were restored with Tetric Ceram by using the incremental layer technique with pressure using a plastic instrument. Each layer was cured for 40 seconds (3000 medicinal Light, 3M).

Groups VI, V, and VI were restored with Renamel composite by placing a layer of Renamel Universal Hybrid to replace the lingual surface and the incisal edge, then complementing it with a layer of Renamel microfill to replace the buccal surface using a plastic instrument. Each layer was cured for 40 seconds (3000 Curing light, 3M).

After finishing is accomplished with diamond burrs (5XF, 55XF Brassler) and polishing points, a surface penetrating sealant Fortify (Bisco Corp.) was applied to the surface of the restoration and cured for 40 seconds. This sealant was used as a thin viscosity unfilled resin for penetration and sealing of any micro fractures generated during placement and finishing procedures.

The completed specimens were placed in water for a week in accordance to the standards established by Koike.[49]

Shear-bond strength testing

An Instron 4202 Testing Machine (Instron® Testing Machine, Instron Engineering Corp., Canton, MA) was used to test the strength of the preparations. The block containing the restored tooth was secured to a mounting jig to provide a 90˚ angle between the incisal edge of the restoration and the Instron testing crosshead.

A line was drawn on the restoration in a specific location to position the cross head of the Instron machine. The Instron crosshead was aligned to contact the buccal surface close to the mesial incisal angle of the restoration during testing at a predetermined line that is drawn in a similar fashion to the simulated mesial fracture, Figure 6. The Instron Machine moved at a speed of 0.5 mm/min, until the specimen fractures.[32] The Instron machine gave a numeric result, which is the peak force (Newton) that was needed to fracture the restoration.

Fractured surface area measurement

Using a digital camera (SONY-Cyber shot 3.3), photographs were taken of the fractured specimens in a standardized position, distance, and magnification. These images were inserted into a software released by NIH (Image-J) to measure the irregular surface area (mm^2) of the fractured segment. Shear strength then was calculated according to the following formula:

$$\text{Shear Strength (MPa)} = \frac{\text{Force (Newton)}}{\text{Surface Area (mm}^2\text{)}}$$

Figure 6. Position of the Instron crosshead on the restoration.

Statistical Analysis

The data presented for analysis were the recorded "shear strength" scores measured in MPA units from 102 teeth randomly assigned to treatment groups of seventeen (17) teeth per group. The teeth in each group were prepared for restoration using one of three preparation techniques and filled with one of two restorative materials resulting in six (6) independent samples as follows:

Group Technique	Preparation Material Used	Restorative
1	Plain Chamfer	Tetric
2	Plain Chamfer	Renamel
3	Buccal stair-step chamfer	Tetric
4	Buccal stair-step chamfer	Rename
5	Buccal and lingual stair-step chamfer	Tetric
6	Buccal and lingual stair-step chamfer	Renamel

Comparative analysis was performed using the procedures of a Two-Factorial (AB) Analysis of Variance for Independent Samples. Many experimental designs consist of studying the influence of a set of independent variables on a response (dependent) variable. These designs look at the influence of a single independent variable (factor) while holding other factors constant. A second type of design, considers the impact of one factor across several values of other factors hence the name factorial design.

The factorial design is widely used because it not only lets you study the individual effects of several factors in a single experiment, but it also lets you study the interaction. Interaction is present when the response variable fails to behave the same at values of one factor when a second factor is varied. Since factors do not often work independently, the interaction becomes an important part of the test.

RESULTS

Descriptive statistics for each independent group are shown in Table V. Figure 7 is a graphic of the average "shear strength" for restorative materials only (disregarding preparation technique). Figure 8 is a graphic of the average "shear strength" for the preparation technique only (disregarding material). Figure 9 is a graphic of the average "shear strength" for each of the six independent treatment groups.

Composite resins

Factor B (Materials) has an F-Ratio of 2.82 and a probability level of 0.0962173 (Table III), indicating no differences in "shear strength" between the two materials used (Figure-8). The AB interaction has an F-ratio of 0.25 and an associated probability level of 0.779197. This simply states that the AB interaction is not significant indicating that differences between the Tetric and Renamel restorative material is consistent within each of the preparation techniques (Table III). In other

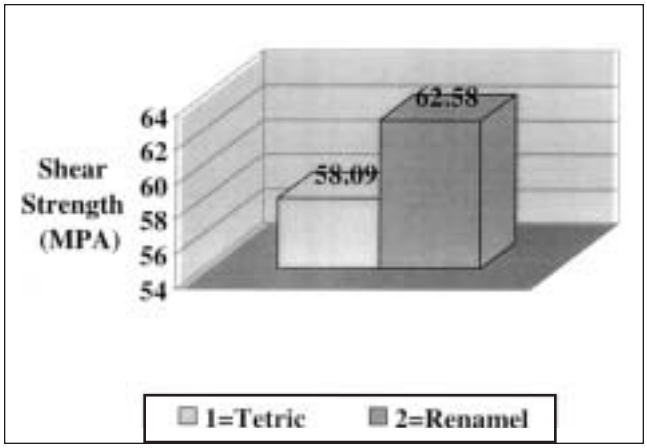


Figure 7. Average Shear Strength of Material Across Preparations

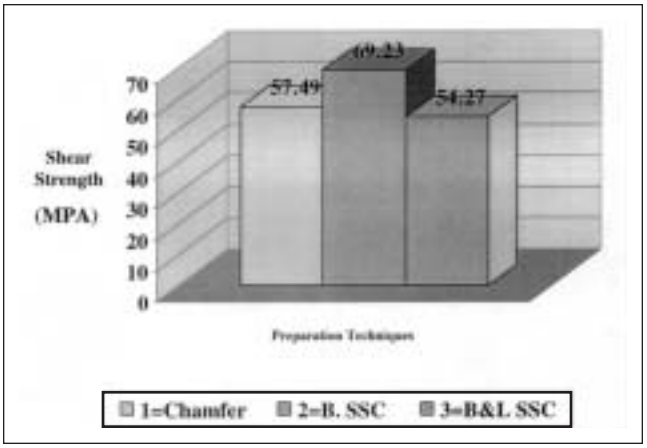


Figure 8. Average Shear Strength of Preparation Technique Across Materials
P. Chamfer = Plain Chamfer
B. SSC = Buccal stair-step chamfer
B&L. SSC = Buccal and lingual stair-step chamfer

words, the differences in "shear strength" among the preparations means, is not due to the influence of material used.

Bonding agents

Each sample was categorized according to the residual composite that is left attached to tooth structure. There were four categories:

1. None, the composite restoration fractured and came off the tooth completely.
2. Buccal, the composite restoration fractured and came off the tooth except the buccal surface.
3. Lingual, the composite restoration fractured and came off the tooth except the lingual surface.
4. Buccal and Lingual, the composite restoration fractured and came of the tooth except for the buccal and lingual surfaces.

According to the results from Table V, it was found that 7% only of the restorations fractured and came off the tooth completely and 93% had some residual composite left attached to tooth structure.

Preparation techniques

The Analysis of Variance Table (Table III) shows that factor A (Preparation) has an F-Ratio of 11.56 and a probability level of 0.000032. This indicates that there is an overall significant difference in mean "shear strength" among the three preparation techniques employed. Having observed at least a single significant effect in the analysis of variance, multiple comparison tests for the significant factor(s) only are performed (Table IV).

It was found that the stair-step chamfer preparation technique provided significantly higher shear strength results than the plain chamfer or the buccal and lingual stair-step chamfer preparation techniques.

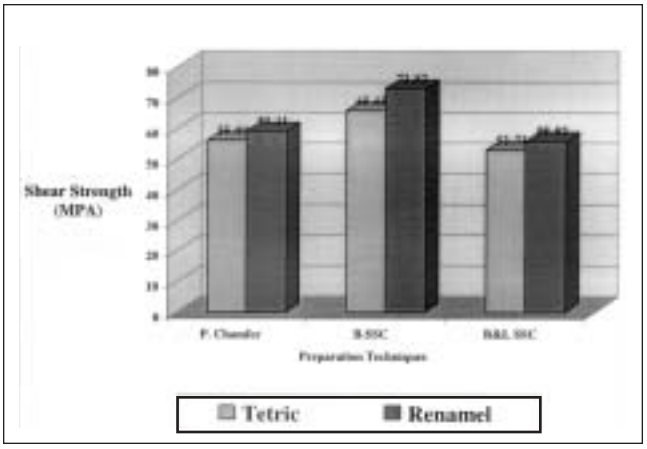


Figure 9. Average Shear Strength of Preparations By Materials
P. Chamfer = Plain Chamfer
B. SSC = Buccal stair-step chamfer
B&L. SSC = Buccal and lingual stair-step chamfer

Table III. Analysis of Variance Table for all six groups

Source Term	DF	Sum of Squares	Mean Square	F-Ratio	Prob. Level
A: Preparation	2	4216.019	2108.01	11.56	0.000032*
B: Material	1	514.8911	514.8911	2.82	0.096173
AB	2	91.24652	45.62326	0.25	0.779197
S	96	17509.47	182.3903		
Total (Adjusted)	101	22331.63			
Total	102				

Table IV. Bonferroni (All-Pairwise) Multiple Comparison Test

Variable: Shear Strength
Factor A: Preparation Across Material
Alpha=0.050, Error Term=S, DF=96, MSE=182.3903, Critical Diff. Value=2.436654

Group	Count	Mean	Different From Groups
1= Plain Chamfer	34	57.49735	2
2= Buccal stair-step chamfer	34	69.23383	3, 1
3= Buccal and lingual stair-step chamfer	34	54.27206	2

Table V. Position of residual composite after the fracture.

	Position of residual composite after the fracture			
	A- None	B- Buccal	C- Lingual	D- Buccal & Lingual
Plain Chamfer + Tetric	(0) 0%	(14) 83%	(0) 0%	(3) 17%
Plain Chamfer + Renamel	(0) 0%	(10) 59%	(1) 6%	(6) 35%
Buccal SSC + Tetric	(2) 11%	(10) 59%	(0) 0%	(5) 30%
Buccal SSC + Renamel	(2) 11%	(8) 47%	(0) 0%	(7) 42%
B&L. SSC + Tetric	(2) 11%	(9) 53%	(0) 0%	(6) 36%
B&L. SSC + Renamel	(1) 6%	(8) 47%	(0) 0%	(8) 47%
Average	(7) 7%	(59) 58%	(1) 1%	(35) 34%

DISCUSSION

Intact human central incisors are difficult to obtain in adequate quantities to perform wide scale experiments, thus complicating *in vitro* studies. Nevertheless bovine incisors offer a suitable and compatible replacement to test shear strength of bonded composite resin restorations.

Three criteria have the greatest effect on shear strength and fracture resistance in anterior teeth, materials, bonding agents, and preparation techniques.

Clinicians struggled to find the ideal combination to restore these types of fractures and to have a sound, esthetic, and functional restoration.

Composite materials

The composite materials that were utilized in this research had the following criteria:

Renamel Microfill: 80% filled by volume, and 60 % filled by weight. Size of the particle is 0.02-0.04 microns.

Renamel Hybrid: 75 % filled by weight. Size of filler particles is 0.04 – 3.0 microns, with a mean particle size 0.7µ.

Tetric Ceram (Hybrid): 60% by volume and 80 % filled by weight. Size of particle is 0.04 – 3.0 microns, with a mean particle size 0.7µ.

The two hybrid materials enjoy the same qualities form the particle size and filler content, they both range around 10,000 MPA modulus of elasticity.

The first null hypothesis showed no significant difference between the hybrid composite restoring material and the combination of a hybrid and a microfill restoring materials when compared for shear strength.

The second null hypothesis showed no significant difference between the six groups as an interrelation between the preparation technique and the restoring material from a shear strength standpoint.

There was no significant difference in shear strength with all types of preparation techniques between the Renamel combination of a hybrid and a microfill composite materials and the Tetric hybrid composite material.

Jordan, *et al* [47] in an *in vivo* study showed that the material used did not have a significant effect on the life expectancy of the restoration, given proper control of variables such as preparation, handling of the material and occlusion.

Both hybrid materials were placed in the stress baring area on the lingual and incisal surface area. The placement of the microfill Renamel on the facial surface did not make a significant difference in the resistance to dislodgement, although it provided better retention figures.

In conclusion the material used did not make a statistical difference in shear strength between the preparations. That carries a huge difference from the point of view of the clinician, where they can use a hybrid composite or a combination of a hybrid and a microfill composite materials in conjunction with chamfer preparations. Nevertheless the microfill composite provides a nicer finish and luster and a better esthetic appearance.

Bonding agents

When applying a continuous force on the restored tooth, given the time needed, eventually something is going to fracture whether it is the restorative material, the tooth, both the tooth and the material or the interface between them. Only 7% of the entire sample size had the restoration fracture completely off the tooth structure showing adhesion failure on the interface between the restorative material and the tooth. But mostly there was a cohesion failure where the composite fractured within itself, leaving some material attached to the tooth.

The previous results were similar to the results showed by Donly and Browning,[20] where they found that 75% of the fractures happened in the composite resin, and not on the interface.

These facts are important from the point of view of the clinician due to the objection of some authors for removing more tooth structure.[4,7,13,56,59,67,71,72] In case of repeated trauma to a tooth that is restored utilizing the stair-step chamfer preparation technique, some of the composite restoration material as shown in Table V stayed attached to the buccal surface of the tooth

where most of the new chamfer is going to be placed conserving tooth structure. While in case of repeated trauma to a weaker preparation technique where minimal tooth structure is removed, or to a tooth that did not have any kind of preparation in the beginning, these teeth will need additional enamel and dentin removal for added retention.

There was no significant difference between the groups in the distribution of the fracture site (Table V), between the material coming off completely or partial fracture of the restoring material off the tooth.

Utilizing the fifth generation of the bonding agents with a hybrid composite material or a combination of a hybrid and a microfill composite materials showed impressive results in shear strength.

Preparation technique

Various authors,[1,11,45-47] reported the use of different preparation techniques. Some advocated the bevel due to its conservative approach especially to traumatized teeth and to the gradient color change from tooth matter to the restoring material. On the other hand, the fragile margins of the restoring material frequently deteriorate over the years.

Bagheri and Denehy,[8,9] in two different studies showed that increasing the thickness of the bevel not the length had a significant difference on shear strength, approximating by that the chamfer preparation design.

Others utilized the plain chamfer technique because it provides more bulk to the restoring material on the margins. However, it fails to blend with tooth color on the fracture line where the enamel and composite interface is visible.

Albers[1] in 1996 presented the buccal stair-step chamfer preparation for esthetic reasons. The chamfer line follows the anatomical contours of the natural human incisor on the buccal surface, while having a plane chamfer on the lingual surface.

The results confirmed one hypothesis and two null hypotheses in this research. The hypothesis that was proved showed that the buccal stair-step chamfer preparation provided greater restoration fracture resistance than the plain chamfered preparation with both hybrid composites and the combination of a hybrid composite and a microfill composite.

The stair step chamfer preparation provided greater surface area to bond, thus increasing the shear strength for the restoration. However, increasing the surface area to bond to in the buccal and lingual stair-step preparation technique by creating the steps on the lingual surface provided significantly less shear strength and fracture resistance, because the preparation technique necessitates more enamel and dentin removal leaving less tooth structure to support the restoration.

Part of the difference between this study and the previous study that was conducted by Eid,[24] that the surface area was measured in a more accurate method using the surface recognition software (Image-J), another factor was the standardization of the placement of the fracture and then correlating that position to the one established for the Instron testing machine. Additionally, the use of similar size crowns versus multiple size crowns should affect the surface area in a more drastic manner.

Future projects should include finding the ideal material that complements the stair-step chamfer preparation technique. Balancing the cohesion and adhesion failures in composite restorations, by utilizing a material with higher compressive strength, like ceramics. Future studies should also include studying the effect of varying bonding agents in conjunction with the stair step preparation technique.

Beauty is in the eye of the beholder, nevertheless studying the esthetics of various preparation techniques and composite materials *in vivo* would contribute a lot to the choice of clinicians when restoring anterior teeth fractures.

Another project is to have an *in vivo* long-term study of the retention of bonded composite resin materials to teeth that received stair-step chamfer preparation technique.

Clinicians would find it most beneficial to use the buccal stair-step chamfer preparation in conjunction with fifth generation bonding agent and a combination of a hybrid and a microfill composite materials to achieve an ideal restoration in this era.

The buccal stair-step chamfer preparation also provided greater restoration fracture resistance than the buccal and lingual stair-step chamfer with both hybrid composites and the combination of a hybrid composite and a microfill composite.

CONCLUSION

1. Buccal stair-step preparation technique provided the ideal preparation technique with bonded composite resins in anterior teeth fractures.
2. Only 7% of the entire sample size had an adhesion failure versus 93% that had cohesion failure.
3. There was no significant difference in shear strength, between the restorative materials used, in conjunction with all the preparation techniques.
4. Buccal stair-step chamfer preparation technique provided significantly higher shear strength and resistance to fracture than the plain chamfer preparation technique.
5. Buccal stair-step chamfer preparation technique provided significantly higher shear strength and resistance to fracture than the buccal and lingual stair-step chamfer preparation technique.
6. There was no significant difference between the Tetric hybrid composite resin material and the Renamel combination of a hybrid and a microfill composite resin materials, in shear strength.

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