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Comparative Evaluation of Microleakage and Bond Strength of Activa and Vitremer in Primary Molars; An in Vitro Study

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KEYWORDS

Primary teeth; Microleakage; Shear bond strength; Glass ionomer cement; Resin modified glass ionomer cement

ABSTRACT:

Aim: The aim of the study is to compare and evaluate microleakage and shear bond strength of ACTIVA and VITREMER in primary molars.

Method: 120 human primary molars were randomly divided into two groups for evaluating microleakage and shear bond strength. Microleakage was assessed using dye penetration technique, and shear bond strength was evaluated on enamel and dentin. Statistical analyses were performed to compare the two restorative materials, ACTIVA and Vitremer.

Results: Results showed no significant difference in microleakage between the materials, but ACTIVA exhibited superior bond strength on enamel compared to Vitremer.

Conclusion: The study concludes that ACTIVA has advantages in reducing microleakage and improving bond strength, suggesting its potential for use in pediatric dental practice, contributing to the literature on bioactive materials in dental restorations.

Introduction

Dental caries, a prevalent issue in children and adolescents, is traditionally treated with different restorative materials. Dental caries arises from, bacterial biofilm changes due to fermentable carbohydrates, causing imbalance in demineralization and remineralization potential. Restorations aim to remove decay carious tissue, bacteria and fill the cavity with a suitable material to restore function and aesthetics, prevent caries recurrence, and protect tooth structure. Factors influencing treatment include caries risk, dentition development, patient cooperation, parental compliance, and choice of material. Restorative dentistry has shifted from invasive to minimally invasive approaches, with advancements in diagnostics and adhesion technology.[1]Dentin substitutes are continually improved for restoring lost tooth structure, requiring properties like adhesion, marginal adaptation, aesthetics, wear resistance, and biocompatibility.[2] Bioactive materials, stimulating dental tissue repair, offer alternatives to inert materials, catering to pediatric dentistry's challenges. Materials like glass ionomer cement and composite resin are widely used but have limitations like polymerization shrinkage and technique sensitivity.[3] Resin-modified glass ionomer cements overcome some drawbacks, offering improved mechanical properties and fluoride release. The introduction of bioactive materials, such as Activa, combines the benefits of composites and glass ionomers, promoting tooth repair and sealing against bacteria.[4] Achieving a stable bond and marginal seal is crucial for restoration success, with factors like microleakage influencing longevity.[5] Microleakage, commonly associated with restoration failure, occurs due to poor adaptation between the material and tooth structure, leading to secondary caries and other

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complications.[6] Shear bond strength testing assesses material bonding under chewing forces, crucial for evaluating restorative performance.[7] In vitro studies comparing bioactive glass ionomers like Activa with conventional materials like RMGIC (Vitremer) aim to evaluate their efficacy in Class II restorations of primary molars, considering microleakage and shear bond strength.

Material and Methodology

The study conducted at Department of Pediatric and Preventive Dentistry of Daswani Dental College and Research Centre, aimed to compare microleakage and shear bond strength of ACTIVA Bioactive restorative material and VITREMER (RMGIC) in primary molars.120 extracted human primary molars were taken meeting specific criteria.

Inclusion Criteria: Intact marginal ridge, bifurcation, and dentinal wall around the pulp chamber. Inclusion criteria ensured teeth's integrity whereas,

Exclusion criteria ruled out unrestorable teeth or those with pulpal involvement.

After teeth selection, teeth underwent clinical and radiographic examination, cleaning, and storage in 0.1% thymol solution for up to 4 months.Later they were divided into two groups: one for microleakage evaluation and another for shear bond strength assessment. Each group was further divided into subgroups based on the restorative material used and the surface evaluated (enamel or dentin).

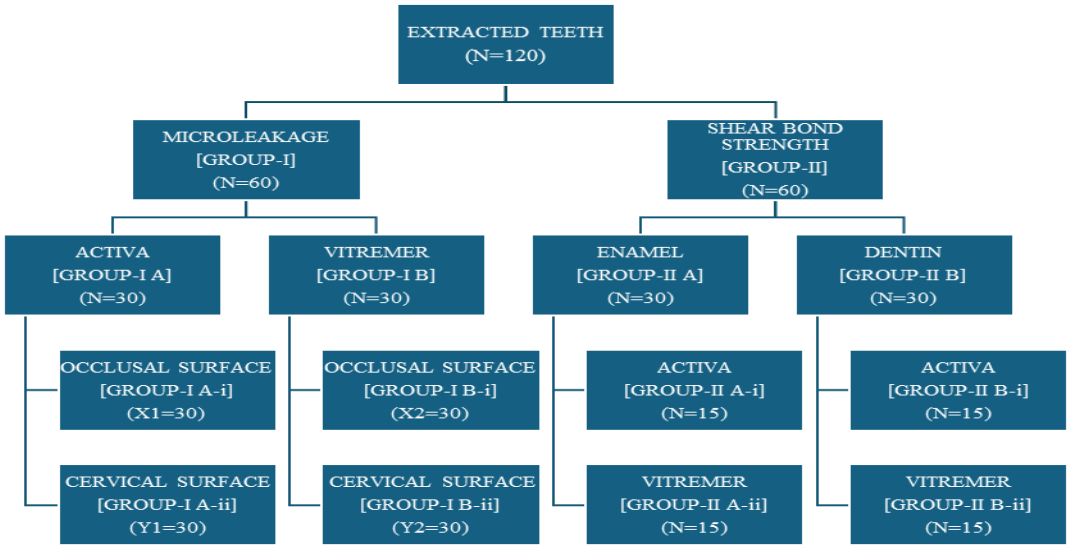

Figure 1. Flow chart of the study

The microleakage assessment involved preparing Class II cavities on 60 primary molars (fig.2), followed by restoration placement according to manufacturer instructions (fig.3). After finishing and polishing, teeth were stored and subjected to thermal cycling. Each tooth was isolated and immersed in methylene blue dye solution, then sectioned longitudinally to assess dye penetration at occlusal and cervical margins and checked under Stereomicroscope.Leakage was scored on a scale from 0 to 3 by one examiner (table.1).

Table1. The scoring system used to evaluate dye penetration under the stereomicroscope.

The scoring system used to evaluate dye penetration under the stereomicroscope	
SCORE	DEGREE OF DYE
0	No dye penetration
1	Dye penetration less than half the axial/gingival wall
2	Dye penetration more than half the axial/gingival wall
3	Dye penetration spreading along the axial/gingival wall

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Figure 2. Class II cavity preparation

Figure 3. Restoration of the Cavity

For shear bond strength testing, 60 specimens were divided into enamel and dentin groups (fig.4). Enamel surfaces were either micro-abraded or trimmed to expose dentin, then polished. Specimens were embedded in acrylic, and a Teflon mold was used to place restorative materials (fig.5,6). After curing, shear bond strength was assessed using a Universal Testing Machine, recording values upon restoration failure. Results were tabulated and statistically analysed.

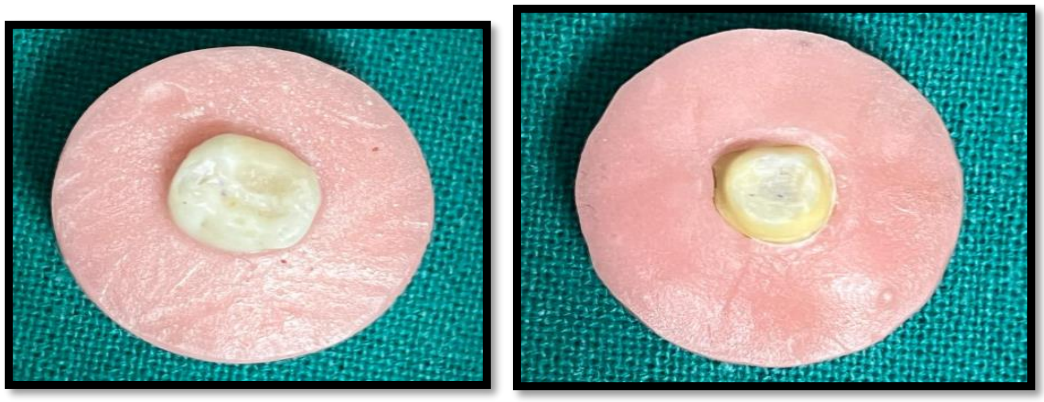

Figure 4. Sample for SBS with microabradedENAMEL& DENTINrespectively

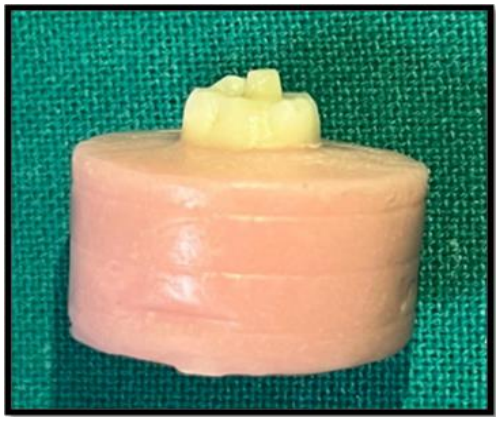

Figure 5. SBS Enamel sample with restoration

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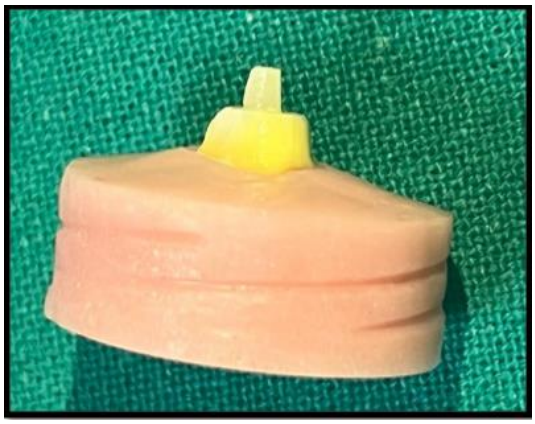

Figure 6. SBS Dentin sample with restoration

Result

I. MICROLEAKAGE

1. Microleakage of restoration in primary tooth using ACTIVA-restorative on OCCLUSAL surface.

Table. 2 Shows the scoring values of Microleakage on occlusal surface and the number of teeth falling in each group, where the score-3 is the most showed i.e. from 17 teeth (56.66%) whereas score-0 (no microleakage) is showed by 4 teeth (13.33%)

2. Microleakage of restoration in primary tooth using ACTIVA-restorative on CERVICAL surface.

Table. 3 Shows the scoring values of Microleakage on cervical surface and the number of teeth falling in each group, where the score-3 is the most showed i.e. from 15 teeth (50%) whereas score-0 (no microleakage) is showed by 8 teeth (26.66%)

3. Microleakage of restoration in primary tooth using VITREMER-restorative on OCCLUSAL surface.

Table. 2 Shows the scoring values of Microleakage on occlusal surface and the number of teeth falling in each group, where the score-3 is showed from 7 teeth (23.33%) whereas score-0 (no microleakage) is showed by 1 tooth (3.33%). Maximum microleakage is showed by score-1 i.e. 20 teeth (66.66%).

4. Microleakage of restoration in primary tooth using VITREMER-restorative on CERVICAL surface.

Table. 3 Shows the scoring values of Microleakage on cervical surface and the number of teeth falling in each group, where the score-3 is showed from 5 teeth (16.66%) whereas score-0 (no microleakage) is showed by 5 teeth (16.66%). Maximum microleakage is showed in score-1 i.e.by 16 teeth (53.33%).

5. Comparing the Microleakage of the restoration in primary tooth using ACTIVA & VITREMER restorative on OCCLUSAL & CERVICAL surface.

Table. 2 Percentage of overall Occlusal leakage of ACTIVA & VITREMER restorative

MATERIAL	OCCLUSAL LEAKAGE (X1+X2)				
	SCORE 0	SCORE 1	SCORE 2	SCORE 3	SCORE 1,2,3
ACTIVA	4	8	1	17	26
VITREMER	1	20	2	7	29
TOTAL	5 8.34%				55 91.66%

Out of total 60 occlusal surfaces, leakage percentage was 91.66% while 8.34% surfaces showed no leakage. According to pairwise comparison, ACTIVA showed lower leakage than VITREMER (p value = 0.003).

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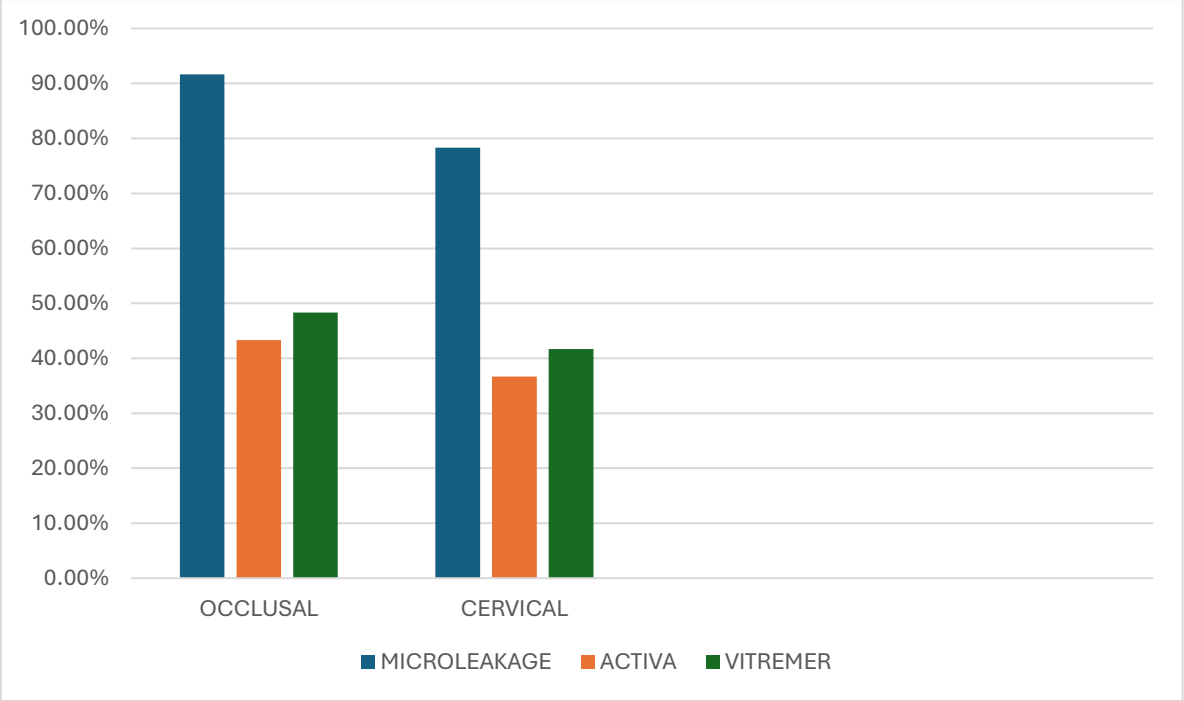
Table. 3 Percentage of overall Cervical leakage of ACTIVA & VITREMER restorative

MATERIAL	CERVICAL LEAKAGE (Y1+Y2)				
	SCORE 0	SCORE 1	SCORE 2	SCORE 3	SCORE 1,2,3
ACTIVA	8	6	1	15	22
VITREMER	5	16	4	5	25
TOTAL	13 21.67%				47 78.33%

Out of total 60 cervical surfaces, leakage percentage was 78.33% while 21.67% surfaces showed no leakage. According to pairwise comparison, ACTIVA showed lower leakage than VITREMER (p value <0.001)

Graph.1 Graph showing percentage of Microleakage of restorations in primary tooth using ACTIVA & VITREMER restorative on OCCLUSAL & CERVICAL surface.



The graph.1 showed the overall microleakage showed at different surfaces i.e. microleakage at occlusal surface (91.66%) and at cervical surface (78.33%)

Following which the amount of microleakage showed by two different materials (ACTIVA & VITREMER) is shown on two surfaces (OCCLUSAL & CERVICAL)

II. SHEAR BOND STRENGTH

Shear Bond Strength of ACTIVA-Restorative (N=30)

1. Shear Bond Strength of ACTIVA-Bioactive restorative material on Enamel surface of primary molar etched with 37% phosphoric acid. (E1=15)

- Mean bond strength of ACTIVA-Bioactive restorative on Enamel surface is**18.55 MPa** (E1).

2. Shear Bond Strength of ACTIVA-Bioactive restorative material on Dentin surface of primary molar with self-etch bond. (D1=15)

- Mean bond strength of ACTIVA-Bioactive restorative on Dentin surface is**16.06 MPa** (D1).

Shear Bond Strength of VITREMER-Restorative (N=30)

3. Shear bond Strength of VITREMER-Restorative on Enamel surface of primary molar etched with 37% phosphoric acid. (E2=15)

- Mean Shear bond Strength of VITREMER-Restorative on Enamel surface is **12.14 MPa** (E2).

4. Shear bond Strength of VITREMER-Restorative on Dentin surface of primary molar with self-etch bond (D2=15)

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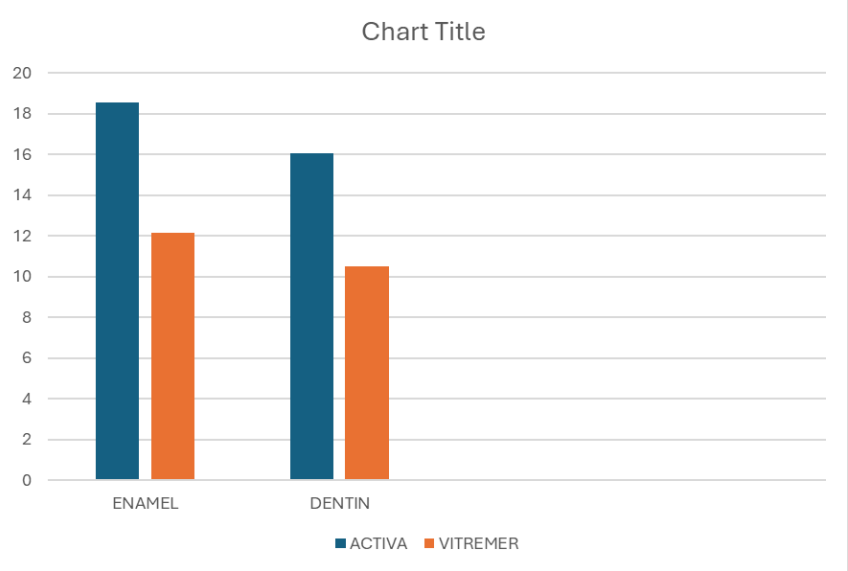
- Mean Shear bond Strength of VITREMER-Restorative on Dentin surface is **10.53 MPa** (D2).

5. Comparing the shear bond strength of the restoration in primary molars using ACTIVA & VITREMER restorative material on Enamel & Dentin surfaces.

Table. 4 Mean shear bond strength of ACTIVA & VITREMER restorative on Enamel & Dentin surfaces.

MEAN SHEAR BOND STRENGTH		
MATERIAL	**ENAMEL** (MPa)	**DENTIN** (MPa)
ACTIVA	18.55 MPa	16.06 MPa
VITREMER	12.14 MPa	10.53 MPa
***p-VALUE**	0.001<0.05 SIGNIFICANT	1.00>0.05 NON-SIGNIFICANT

Graph. 2 Graph showing mean SBS of ACTIVA & VITREMER on Enamel & Dentin surface.



The graph.2 shows the mean shear bond strength of ACTIVA & VITREMER at two different surfaces i.e. at ENAMEL & DENTIN.

Discussion

ACTIVA-Bioactive composite was chosen as the experimental comparison to VITREMER not only for its bioactive properties (capability of releasing fluoride) but also for its low polymerization shrinkage (1.7%) and high depth of light cure (4 mm), which allow for bigger increments and less time to complete the restoration.[8] Because of these properties, this material has many indications for class I and class II caries in primary molars. According to the manufacturer, this material is also indicated in cases where the isolation is compromised or impossible and in patients with high caries index due to its fluoride-releasing properties.

120 extracted human primary molars were taken based on the inclusion criteria and 0.1% thymol was used to store teeth for not more than 4 months, as**Haller et al. 1993**[9] reported that microleakage scores in teeth stored in 0.1% thymol were not different from the microleakage scores of freshly extracted teeth; making it an appropriate medium for storage of extracted teeth for use in dentin bonding laboratory studies. Later, teeth were randomly divided into two groups for further progress of the study.

As part of an aging protocol, teeth were subjected to 500 cycles of thermal cycling, which showed no difference in results from 500-1000 cycles suggestive of the studies by **Yap 1998; Bala et al. 2013**[10,11]and keeping the temperature range of 5–55 °C, which is recommended by **Longman and Pearson 1987**[12] as the ideal temperature extremes close to the oral conditions.

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In our study the microleakage showed by both the materials was not statistically significant. The microleakage of ACTIVA on occlusal surface was 86.66% and on cervical surface was 73.33%, whereas the microleakage of VITREMER on occlusal surface was 96.66% and on cervical surface was 83.33%

One of the major factor that cause microleakage is immediate finishing and polishing of the restoration which was done according to manufacturer's instruction.**Irie and Suzuki 2002**[13] found a notable increase in gap occurrence at the restoration margin for both conventional and resin-modified glass ionomers when polished immediately compared to polishing after a delay of 24hrs. Similarly, **Yap and Mok 2002**[14] emphasized this phenomenon and advocated for standardizing the finishing and polishing protocol for adhesive restorations.

For dye penetration we used methylene blue, and the leakage was noted to be at higher side than comparing to the microleakage study of **Khoroushi et al. 2012**[15], reported a total of 71.4% leakage at enamel margin in the RMGI group with the use of the conventional cavity conditioner. However, they used permanent maxillary premolars immersed in 2% basic fuchsin dye, which may be a reason for such differences in leakage values.

Talking about bonding efficiency and dislodgement of restoration, **Van Dijken and Pallesen 2008**[16] in a 13-year follow-up clinical trial andthe total loss rate of the restorative material (RMGI) after 13 years, which was the determinant of the bonding efficiency, was 53%. Vitremer achieved the least annual failure rate (2.7%). The authors concluded that the best dentin retention was achieved by Vitremer and a four-step etch-and-rinse system.

ACTIVA is suggested to be an advance in the field of restorative dentistry by combining strength and esthetics of composite and all the benefits of RMGI. According to the analysis per teeth, differences in leakage percentages between ACTIVA and Vitremer were not statistically significant. However, by analyzing leakage percentages per sections, ACTIVA showed significantly lower leakage compared to Vitremer at occlusal margin and similar at cervical margin.

In cases of box/slot/class II cavities, **Omidi et al.2018**[17] evaluated and compared the microleakage with ACTIVA BioACTIVE restorative, resin-modified glass ionomer, and composite in primary molars. The study concluded that microleakage of ACTIVA BioACTIVE restorative material in the absence or presence of etching and bonding could be comparable to the microleakage of composites, whereas, in a similar study **Bhadra et al. 2018**[18] evaluated and compared the clinical performance of a nanohybrid composite with ACTIVA BioACTIVE restorative material in Class II cavities of permanent molars. The trial concluded that both materials showed equal and acceptable clinical performance at the end of 1year.

The shear bond strength was assessed in a custom apparatus attached to a universal testing machine. The results showed that mean shear bond strength of **ACTIVA** on ENAMEL was 18.55 MPa and DENTIN was 16.06 MPa. The present study showed that shear bond strength of **VITREMER-RMGIC** on ENAMEL was 12.14 MPa and 10.53 MPa on DENTIN.

The present study is in accordance with the study conducted by **Gisovar et al 2014**[19], the shear bond strength of etch-and-rinse adhesive systems were higher than self-etch adhesives which is similar to this study in which etch and rinse adhesive system shows better shear bond strength than self-etch adhesives. This is due to formation of a hybrid layer and resin tags which is essential for the establishment of a strong bond at the dentin level and may be achieved by complete dissolution of the smear layer and demineralization of intratubular and peritubular dentin by means of acid etching technique, resulting in an exposed collagen matrix which is then infiltrated by resin.

The Shear bond strength of RMGIC was increased when the dentin surface is acid etched separately**Di Nicolo R et al 2008**[20], which in accordance with the present study in which shear bond strength was more in VITREMER on Enamel.

The results of our study are in discordance with a study by **Sahar Abd El Halim 2018**[21] in which a nanocomposite (Filtek™ Z350 XT) exhibits a higher shear bond strength than Activa BioActive Restorative with adhesive.

Theself-adhesive property of ACTIVA Bioactive Restorative is non-existent**Benetti AR, et al. 2019**[22]. In this study, when Activa Bioactive Restorative was placed directly without a bonding agent, restorations were lost during fabrication of specimens. These findings contradict the self-adhesion capability claimed by the manufacturer.

Philippe François et al. 2021[23] showed that Activa BioActive Restorative with a bonding agent presented

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higher SBS than Activa BioActive Restorative without a bonding agent.A study conducted by **Afutu et al. 2019**[24] reported higher SBS of ACTIVA KIDS to dentin as compared to GIC (Fuji IX GP Extra). The better performance of ACTIVA restorative material was attributed to its adhesion mechanism and improved mechanical characteristics.

In the present study, the use of the self-etch adhesive prior to restoration with ACTIVA BioACTIVE Restorative resulted in comparable marginal adaptation with that of control composite restorations, as observed by **Kaushik and Yadav 2017**.[25]

Conclusion

The research investigates the microleakage and shear bond strength of a novel material, ACTIVA, which combines the benefits of composite resins and glass ionomers. This hybrid material shows promise in pediatric dentistry, addressing challenges of composite resin application and meeting expectations for aesthetics and durability. However, caution is advised when applying these findings clinically due to notable microleakage issues with ACTIVA. While laboratory tests provide insights, differences between lab and clinical conditions require careful interpretation. Overall, ACTIVA demonstrates superior shear bond strength and lower microleakage compared to VITREMER, making it a preferred option considering various attributes.

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