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Comparative Evaluation of Flexural Strength and Surface Microhardness of Temporary Dental Disocclusion Materials with and Without Thermocycling - An in Vitro Study

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Introduction

In Orthodontics, there are several indications for bite opening. Fixed appliances, though small, can interfere with occlusion and function, potentially causing tooth abrasion or bracket debonding. To prevent occlusal interferences from damaging mandibular brackets, temporary dental disocclusion is often necessary. This facilitates tooth movement that may otherwise be restricted by deep bites, telescopic bites, buccal non-occlusions, or crossbites.[1]

Orthodontic bite raisers are specially designed surfaces placed anteriorly or posteriorly to create a contact plane that prevents full jaw closure.[2] While removable bite plates require patient compliance and laboratory fabrication, many orthodontists now prefer directly bonded materials like composite resins and glass ionomers due to their ease of use and improved bonding techniques. These bonded attachments are actually commonly known as “bite turbos.”[3]

A wide range of composite materials is available for both direct and indirect bonding, valued for their favorable physical and mechanical properties. These composites typically consist of an organic polymatrix, inorganic fillers, and a silane coupling agent. Their mechanical behavior is closely tied to composition and also microstructure. Nanofilled composites, which contain uniformly dispersed nanosized particles, offer better protection to the matrix due to reduced inter particle spacing. As a result, they exhibit enhanced wear resistance and microhardness.[4] Orthodontic composites like Orthobite and Orthocem also offer additional advantages such as pigmentation and fluorescence, which facilitate easy identification and removal of bite turbos after treatment without causing iatrogenic damage.[5]

In the oral environment, materials undergo cyclic stress due to exposure to hot and cold foods and beverages such as tea, coffee, juices, and carbonated drinks. These conditions can alter the properties of materials used intraorally. Although bite raisers are temporary, their mechanical performance—particularly flexural strength and surface microhardness—is critical. These parameters should be key considerations for clinicians selecting adhesives for bite-raising applications.[6]

Therefore, the purpose of the study is to compare and evaluate the effect of temperature variation on flexural strength and surface microhardness of five different materials used for making a temporary dental disocclusion.

Material and Methodology

Sample preparation

This in-vitro study was done in the Department of Orthodontics and Dentofacial Orthopaedics in Government Dental College and Hospital, Afzalgunj, Hyderabad.

The materials and equipment utilized in the study included a variety of dental composites and specialized instruments. Vitrebond, Transbond Plus color change adhesive, Filtek Supreme, Orthobite (a blue-colored resin composite), and Orthocem (a UV resin composite) were used as restorative and adhesive materials. Distilled water served as the immersion medium for sample storage, simulating intraoral conditions. Samples were prepared on standard glass slides measuring 75 mm × 50 mm × 1 mm and then secured using a bipartite metallic matrix. A Teflon-coated composite instrument was employed for manipulation of the composites, while a polyester strip was used to achieve a smooth surface finish.

To simulate the oral environment, the specimens were immersed in distilled water and incubated at 37°C. Light polymerization was performed using an LED curing unit (Woodpecker). Dimensional accuracy and measurements were obtained using a digital vernier caliper (Model - TH-M61). Mechanical testing involved the use of a Universal Testing Machine (INSTRON, Model-1185) to evaluate bond strength, and a Microhardness Testing Machine (CMV-1000) to assess surface hardness of the materials. Additionally, a Thermocycling Machine (CME, Pvt. Ltd.) was used to subject the samples to thermal stresses, thereby mimicking temperature variations encountered in the oral cavity.

Inclusion Criteria

- Samples of five different materials with measurements 25mm×2mm×2mm.
- Materials compatible with the planned testing methodologies. eg: Flexural strength.
- Resins that are manufactured in compliance with international standard ISO: 4049.

Exclusion Criteria

- Materials beyond expiry date.

Methodology

A total of 100 samples were prepared and divided into five groups (20 specimens each) according to ISO 4049:1988 standards, using a bipartite metallic matrix (25 mm × 2 mm × 2 mm) supported on a glass plate.

Specimen Preparation

- **Vitrebond:** Mixed in a 1.4:1.0 powder-to-liquid ratio and placed into the matrix using a disposable syringe.

A polyester strip and glass slide (75 mm × 50 mm × 1 mm, 1 kg) were placed on top to standardize the sample.

- **Transbond Plus, Filtek Supreme, Orthobite, Orthocem:** Inserted using a Teflon-coated spatula, followed by the same polyester strip and glass slide procedure. Light curing (400 mW/cm²) was performed in four 6 mm increments.

Post-curing, sample dimensions were confirmed using a digital vernier caliper (TH-M61, accuracy 0.01 mm).All specimens were stored in distilled water at 37°C for 24 hours. Half of each group then underwent 1150 thermocycles (5°C–55°C, 30 seconds immersion, 10 seconds interval), simulating 4 months of intraoral conditions. After thermocycling, all samples were again stored at 37°C in distilled water for 24 hours prior to testing.

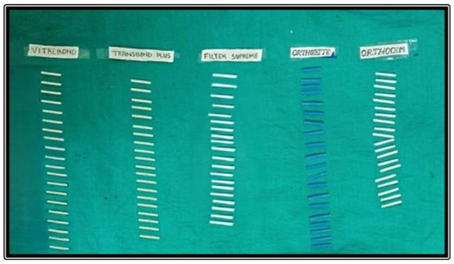


Figure 1: Prepared Sample Specimens of Five Different Groups

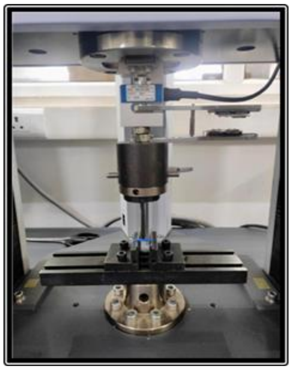


Figure 2: Three Point Bending Test For Flexural Strength

Figure 3: Knoop Hardness Testing Procedure

Flexural Strength Test

Conducted on a Universal Testing Machine (INSTRON Model-1185) with a 20 mm span, applying 5 kN load at 0.5 mm/min until fracture.

Surface Microhardness Test

Performed using a CMV-1000 Microhardness tester with a Knoop diamond indenter, 25 g load, and 10-second dwell time. Three indentations per specimen were made, spaced 100 µm apart.

The Knoop microhardness results were obtained automatically by calculating the following formula:

$KHN = C\,.c/d^2$

KHN = Knoop hardness value,

C (constant) = 14,230,

c = load,

d = length of the longest diagonal of the impression.

The resulting number of Knoop hardness was determined for each specimen by averaging the values obtained from the three impressions.

Results

All the materials except Vitrebond showed significant difference in both flexural strength and surface microhardness tests after thermocyling. (Table 1 & 2 and Graphs 1 & 2)

Table 1: Post-hoc comparison of Mean Flexural Strength Scores between Groups Using One-Way ANOVA

		Sum of Squares	df	Mean Square	F	p-value
Vitrebond	Between Groups	0.625	1	0.625	0.253	0.62
	Within Groups	19.759	8	2.470		
	Total	20.384	9			
Transbond Plus	Between Groups	1644.550	1	1644.550	1906.658	0.001*
	Within Groups	6.900	8	0.863		
	Total	1651.450	9			
Filtek Supreme	Between Groups	2033.476	1	2033.476	1333.991	0.001*
	Within Groups	12.195	8	1.524		
	Total	2045.671	9			
Orthobite	Between Groups	3906.948	1	3906.948	2098.310	0.001*
	Within Groups	14.896	8	1.862		
	Total	3921.843	9			
Orthocem	Between Groups	4535.622	1	4535.622	2192.870	0.001*
	Within Groups	16.547	8	2.068		
	Total	4552.169	9			

*p<0.05 is considered as statistically significant

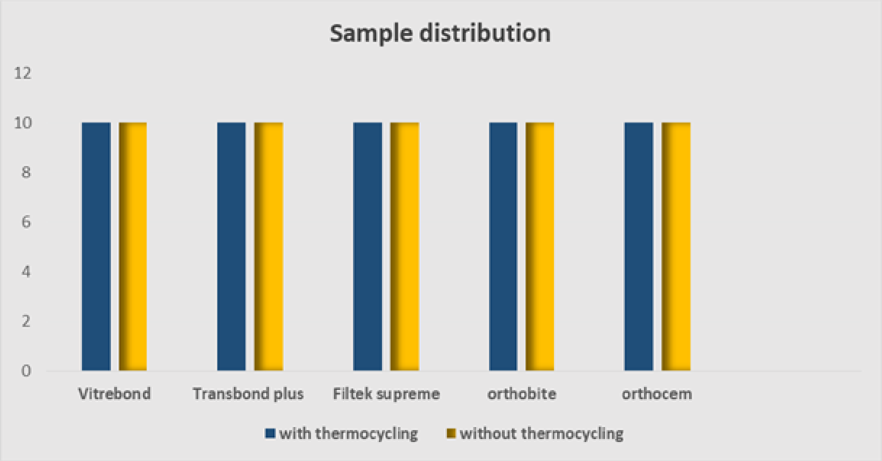
Table 2: Post-hoc comparison of Mean Microhardness Scores between Groups Using One-Way ANOVA

ANOVA						
		Sum of Squares	df	Mean Square	F	p-value
Vitrebond	Between Groups	0.225	1	0.225	0.500	0.50
	Within Groups	3.602	8	0.450		
	Total	3.827	9			
Transbond Plus	Between Groups	150.622	1	150.622	109.419	0.001*
	Within Groups	11.012	8	1.377		
	Total	161.634	9			
Filtek Supreme	Between Groups	149.150	1	149.150	92.264	0.001*
	Within Groups	12.933	8	1.617		
	Total	162.083	9			
Orthobite	Between Groups	26.179	1	26.179	5.061	0.05*
	Within Groups	41.381	8	5.173		

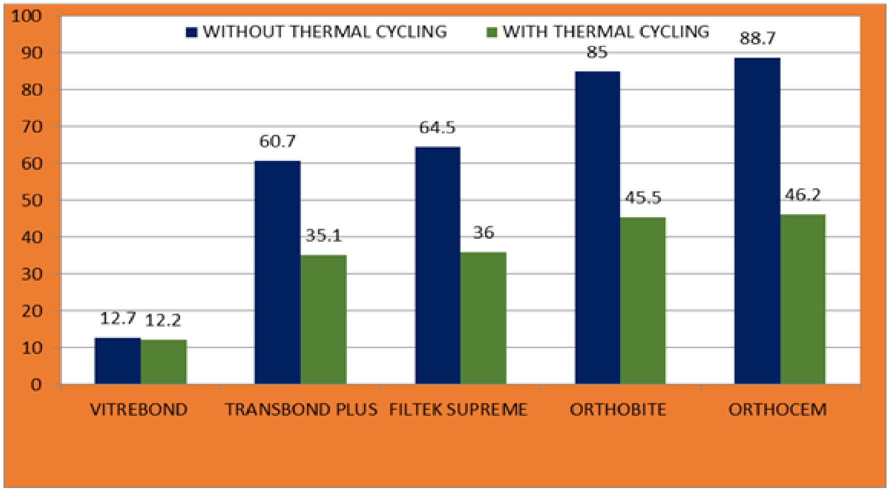
	Total	67.560	9			
Orthocem	Between Groups	32.400	1	32.400	27.576	0.001*
	Within Groups	9.400	8	1.175		
	Total	41.800	9			

*p<0.05 is considered as statistically significant

Graph 1: sample distribution of five groups with and without thermocycling



Graph 2: Comparison of mean flexural strength scores of study groups based on thermal cycling



According to the results of the analysis of variance, the material's flexural strength varied significantly. The variation is dependent on the factors such as material type and temperature effect. Greater the F-ratio, greater is the significance, Hence all the groups except vitrebond showed greater F statistic indicating the level of significance between the groups. According to the tukeys post hoc comparision test, there was no discernible difference in mean resistance between the cycling and non-cycling groups for vitrebond (table 3 & 4).

Table 3: Comparison of Mean Flexural Strength Scores between Groups

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Vitrebond	Without thermal cycling	5	12.7840	1.50334	.67231	10.9174	14.6506	10.34	14.05
	With thermal cycling	5	12.2840	1.63697	.73208	10.2514	14.3166	10.35	14.43
	Total	10	12.5340	1.50495	.47591	11.4574	13.6106	10.34	14.43
Trans Bond Plus	Without thermal cycling	5	60.7840	.92916	.41553	59.6303	61.9377	59.85	62.12
	With thermal cycling	5	35.1360	.92829	.41515	33.9834	36.2886	33.83	36.02
	Total	10	47.9600	13.54601	4.28363	38.2698	57.6502	33.83	62.12
Filtek Supreme	Without thermal cycling	5	64.5440	1.43036	.63968	62.7680	66.3200	62.88	66.45
	With thermal cycling	5	36.0240	1.00139	.44783	34.7806	37.2674	34.67	37.01
	Total	10	50.2840	15.07636	4.76756	39.4990	61.0690	34.67	66.45
Orthobite	Without thermal cycling	5	85.0580	1.09623	.49025	83.6969	86.4191	83.28	86.14
	With thermal cycling	5	45.5260	1.58814	.71024	43.5541	47.4979	43.99	47.86
	Total	10	65.2920	20.87487	6.60121	50.3590	80.2250	43.99	86.14
Orthocem	Without thermal cycling	5	88.7980	.63700	.28488	88.0071	89.5889	87.86	89.35
	With thermal cycling	5	46.2040	1.93156	.86382	43.8056	48.6024	43.56	48.44
	Total	10	67.5010	22.48992	7.11194	51.4127	83.5893	43.56	89.35

Table 4: Comparison of Mean Microhardness Scores between Groups

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Vitrebond	Without thermal cycling	5	46.4120	.60027	.26845	45.6667	47.1573	45.8	47.33

	With thermal cycling	5	46.7120	.73503	.32872	45.7993	47.6247	45.4	47.34
	Total	10	46.5620	.65212	.20622	46.0955	47.0285	45.4	47.34
Transbond Plus	Without thermal cycling	5	65.1220	.62082	.27764	64.3511	65.8929	64.3	66.01
	With thermal cycling	5	57.3600	1.53873	.68814	55.4494	59.2706	55.6	59.32
	Total	10	61.2410	4.23785	1.34012	58.2094	64.2726	55.6	66.01
Filtek Supreme	Without thermal cycling	5	66.4640	1.60265	.71673	64.4740	68.4540	64.8	69.01
	With thermal cycling	5	58.7400	.81526	.36460	57.7277	59.7523	57.6	59.86
	Total	10	62.6020	4.24373	1.34198	59.5662	65.6378	57.6	69.01
Orthobite	Without thermal cycling	5	80.5940	2.31998	1.03753	77.7134	83.4746	77.1	82.45
	With thermal cycling	5	77.3580	2.22775	.99628	74.5919	80.1241	74.5	79.68
	Total	10	78.9760	2.73983	.86641	77.0160	80.9360	74.5	82.45
Orthocem	Without thermal cycling	5	82.3580	1.32686	.59339	80.7105	84.0055	80.1	83.45
	With thermal cycling	5	78.7580	.76767	.34331	77.8048	79.7112	77.8	79.88
	Total	10	80.5580	2.15509	.68150	79.0163	82.0997	77.8	83.45

The cycling groups had significantly lower averages ($P < 0.05$) for the other materials. Orthodontic Composite resins, Orthocem and Orthobite materials had considerably greater resistance than Vitrebond in the thermal cycling groups ($P < 0.05$).

Regarding the microhardness of the materials, (Table 2) the tukey test revealed that the groups that got cycling had considerably lower averages ($p< 0.05$), with the exception of Vitrebond. The average microhardness of the Orthocem was higher than that of the Orthobite in the groups without cycling, however the differences were not statistically significant ($P > 0.05$). The average microhardness was lower in Vitrebond. The mean microhardness of the Vitrebond was lower than that of the other cycling groups, whereas the mean microhardness of the Orthocem and Orthobite materials was significantly higher than the other materials ($P< 0.05$).The cycling groups had decreased means ($P < 0.05$) for microhardness and flexural strength, with the exception of GIC. The Vitrebond demonstrated reduced resistance to bending and microhardness across the non-cycling groups ($P < 0.05$).

Discussion

In orthodontics, bite-opening materials such as composite, compomer, glass ionomer cement (GIC), and self-curing acrylic resin are widely used on occlusal or lingual surfaces to increase the vertical dimension, protect brackets from premature contact, and manage malocclusions like deep bites, crossbites, telescopic bites, and buccal non-occlusions. Anterior and posterior bite turbos are commonly employed to address occlusal interferences, but many of these materials were not originally designed to endure occlusal forces, and their wear resistance remains underexplored.[2]

Anterior resin turbos are commonly bonded to the palatal surfaces of the upper central incisors in patients with horizontal growth patterns to manage deep bites. Bonding both central incisors helps evenly distribute occlusal forces, promotes forward mandibular closure, and minimizes the risk of posterior mandibular displacement.[6] These turbos are typically maintained for 4–6 months, or approximately three months in cases involving anterior crossbites. However, in individuals with vertical growth patterns, their use requires caution due to the potential for unwanted posterior tooth extrusion. Close periodontal monitoring of the mandibular incisors is essential throughout the duration of turbo use.[7]

Posterior bite build-ups help achieve posterior disocclusion, allowing for immediate bracket placement. They facilitate arch leveling in deep bite cases by promoting maxillary incisor extrusion and molar intrusion, aiding in anterior open bite closure. These build-ups are temporary, easily adjustable chairside, and do not require appliance removal.[8]

According to Singh et al.,[9] resin-based bite turbos provide several benefits over conventional acrylic appliances, including improved oral hygiene, reduced chairside time, lower profile, enhanced patient comfort, and less impact on speech. However, these turbos also have limitations, such as the risk of anterior occlusal trauma, potential loss of pulp vitality, posterior tooth intrusion leading to open bite, material wear, breakage, and debonding.

Material selection for bite turbos should be informed by location, duration of application, and wear resistance. Softer materials adapt to occlusal changes and minimize wear on opposing dentition, but may need frequent repair. Conversely, harder materials provide durability but increase risk of enamel abrasion.[5] Material wear is influenced by the hardness of filler particles, resistance to grinding, and oral conditions like humidity and temperature variation, all of which can accelerate material degradation. Therefore, materials must be chosen for their mechanical stability in intraoral environments.[2]

The study assessed five widely used bite-opening materials—Vitrebond, Transbond Plus, Filtek Supreme, Orthobite, and Orthocem—through three-point bending tests and Knoop hardness evaluations, both before and after thermocycling. Knoop hardness testing, which measures a material's resistance to wear under controlled pressure, revealed significant differences. Composite resins showed greater surface hardness than resin-modified GICs (RMGIC), likely due to the presence of silica fillers enhancing wear resistance.[10]

Nanofilled composites demonstrated lower hardness compared to Orthobite and Orthocem, potentially due to impaired polymerization from light scattering by nanofillers and nanoclusters.[10] Surface hardness varied based on composition, light-curing method, and filler distribution. These results align with Rosen et al. (2001)[11], who found composites and compomers generally outperform RMGICs in surface hardness.

Flexural strength—a key property for stress-bearing applications—was evaluated using the three-point bending method, considered the gold standard for its low variability. According to ISO 4049/2009, 80 MPa is the minimum threshold for occlusal materials. Both Orthobite and Orthocem surpassed this benchmark (85.05 MPa and 88.79 MPa respectively), which is attributed to their high filler content, optimized resin viscosity, and effective curing characteristics.

Thermocycling (1150 cycles to simulate four months of oral use) significantly reduced the flexural strength and surface hardness of all materials. While Orthobite and Orthocem performed best prior to thermocycling, all materials deteriorated post-thermocycling. Vitrebond showed the weakest performance both before and after, likely due to its low resin content and limited matrix-filler bonding.[12]

Nanofilled composites showed greater degradation under thermocycling, attributed to higher TEGDMA monomer release, water sorption at filler–matrix interfaces, and their large surface area. These changes result in matrix plasticization, filler detachment, and internal microfractures, weakening the material over time.[6,10]

The mechanical strength of composite resins depends on filler characteristics, monomer composition, and matrix-filler coupling. Despite standardized methods, inconsistencies in resin structure may lead to surface flaws. Compomers, which contain fluorosilicate glass within a methacrylate matrix, demonstrated intermediate performance—better than RMGICs but inferior to composites due to limited light penetration and polymerization.[12]

Among the tested materials, Vitrebond exhibited the least degradation post-thermocycling, likely due to HEMA-induced inhibition of the acid-base reaction, which prevents structural breakdown. However, its mechanical properties remained suboptimal. Orthocem, which contains fluorescent pigments, and Orthobite, pigmented blue, allow easy identification of residual adhesive without impacting performance—a feature supported by studies from Flaviana et al. (2020)[13] and Rossato et al. (2020)[14], Samadi et al. (2019)[15] and Pereira et al. (2007)[16] also confirmed post-thermocycling declines in bond strength and hardness due to water absorption and mismatch in thermal expansion.

Overall, thermocycling significantly compromises composite resin performance, reinforcing the importance of selecting materials with high mechanical resilience for stress-bearing applications such as bite turbos. The study proves that Orthobite and Orthocem offer superior microhardness and flexural strength, making them suitable for long-term orthodontic use. Their performance, durability, and ease of identification make them preferable for managing occlusal discrepancies in clinical practice.

Conclusion

The primary objective of this study was to evaluate and compare the flexural strength and microhardness of five different dental disocclusion materials, both before and after exposure to thermocycling. The study aimed to assess how thermocycling, which simulates the thermal stresses encountered in the oral cavity due to fluctuating temperatures, impacts the mechanical properties of these materials. Upon analysis, it was observed that all the tested materials exhibited significant degradation in their properties following thermocycling. This finding indicates that repeated thermal cycling adversely affects the structural integrity of dental disocclusion materials.

Among the five materials tested, Orthocem and Orthobite demonstrated the highest values of flexural strength, indicating superior resistance to bending and fracture under stress. In contrast, Vitrebond showed the lowest flexural strength, followed by Transbond Plus and Filtek Supreme, which also exhibited comparatively reduced performance. These results suggest that Orthocem and

Orthobite possess enhanced durability and mechanical resilience in comparison to the other tested materials.

With respect to microhardness, which was assessed using the Knoop hardness test, Orthobite and Orthocem again showed the highest values. These values were within the acceptable range as defined by the International Organization for Standardization (ISO), which sets the minimum standard at 80 MPa. On the other hand, Vitrebond recorded the lowest Knoop hardness value among the materials evaluated. This further reinforces the finding that Orthobite and Orthocem are mechanically more robust compared to the other materials.

The study also clearly demonstrated that thermocycling leads to a reduction in both flexural strength and microhardness across all resin-based disocclusion materials. This consistent decline across different material types underscores the importance of considering thermal aging when evaluating the long-term performance of materials used in dental applications.

Based on the results obtained, it can be concluded that Orthobite and Orthocem are the most suitable among the tested materials for use in dental disocclusion procedures, given their higher resistance to mechanical degradation and their ability to maintain acceptable hardness levels even after thermocycling. However, despite these promising findings, the study emphasizes the necessity for further clinical research. Additional long-term in vivo studies are essential to gain a deeper understanding of the mechanical behavior and clinical longevity of dental disocclusion materials under the complex and dynamic conditions of the oral environment.

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