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Comparison Between The Degree Of Cure Of Orthodontic Composite Attachment Underneath Two Different Aligner Attachment Template Material

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Abstract:
Objective: *The main objective of this study is to compare the degree of cure of composite cured under two different aligner attachment templates.*
Materials and Methods
Composite pellets were fabricated to fit into the Fourier Transform Infrared Spectrometer. Putty material was used to form pellets measuring 7 mm in diameter and 3 mm in thickness, which were then thermoformed using Erkolen and Erkodur-al to create attachment wells. Composite(Espe Filtek) was applied in layers and excess material removed before photopolymerization using a light-curing unit (Elipar Visio II). The degree of cure was measured using micro multiple internal reflectance Fourier Transform Infrared Spectrometer (micro-MIR FTIR). Three experimental groups were created:

- *Group I: Cured composite resin without thermoformed sheet*
- *Group II: Cured composite through soft thermoformed sheet (Erkolen)*
- *Group III: Cured composite through hard thermoformed sheet (Erkodur-al)*

Results*: The degree of conversion varied significantly across materials and surfaces. Statistical analysis revealed no significant difference in the degree of conversion between the hard sheet on the aligner side and the hard sheet on the composite side (p = 0.126).*
The composite pellet cured via Erkodur-al exhibited the highest degree of conversion when compared with the composite pellet cured via Erkolen.
Conclusion: *The findings of this study suggest that the type of attachment template influences the degree of polymerization of composite resins, which may impact the stability and effectiveness of clear aligner therapy. Proper selection of attachment template is crucial to optimizing treatment outcomes in orthodontic aligner therapy.*
Key Word: *Degree of cure of composite, Aligner attachments, Thermoformed material, Erkodur-al, Erkolen.*

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I. Introduction

Orthodontic treatment has traditionally focused on correcting dental misalignments, with an emphasis on functionality. However, there has been a significant shift in patient preferences, especially among adults, who are increasingly seeking more aesthetic options. This trend is particularly noticeable in patients over the age of 20 years, who often prefer alternatives to traditional metal braces. Since the introduction of clear aligners in 2005, their aesthetic appeal has made them a popular choice. Despite this, orthodontists continue to prioritize functional outcomes, ensuring that treatments not only improve appearance but also support the long-term health and functionality of the teeth. With the development of new materials, both for aligners and traditional braces, the comfort, effectiveness, and quality of orthodontic treatments have continuously improved, offering patients more customized options. Attachments in clear aligner therapy (CAT) are crucial features designed to enhance aligner retention and improve tooth movement predictability[1]. The properties of the composite resin used to form these

attachments play a critical role in maintaining their integrity and shape over time. Attachments help improve the fit between the aligners and tooth surfaces, enhancing their interaction [2]. Conventional nanocomposites typically offer more uniform attachment profiles, reducing the failure rate of attachments in terms of debonding, shape modification, and wear performance [3].

The assessment of the polymeric adhesives' degree of cure is crucial because a low cure degree is linked to the development of a weak polymer network, which can potentially release harmful substances that may have toxic effects [4]. The degree of cure (DC) in orthodontic adhesives influences the material's physical and mechanical properties, particularly solubility and degradation. These effects are vital for determining the biological performance of the materials [5]. In this study, two different aligner attachment templates, Erkodur-al (hard) and Erkolen (soft), are used and the degree of cure of the composites cured under these two templates are compared.

II. Material And Methods

This is an invitro study. It was conducted in Department of orthodontic, Tagore dental college and hospital, Vandalur, Chennai. This study was approved by Institute Research Committee (Ref No: RC/TDCH/54/2024)

This study aimed to investigate how different attachment templates (soft vs. hard) impact the degree of cure of composite resin during clear aligner therapy. The study was based on the null hypothesis that no significant difference would be found between the degree of cure of composite under clear aligner and soft splint templates, suggesting both would achieve similar levels of conformity.

To evaluate the degree of cure of composite resin under two different attachment templates, putty material was used to create pellets with dimensions of 7mm diameter and 3mm thickness. Erkolen and Erkodur-al sheets were thermoformed over the putty pellets to form the attachment wells, in which the composite resin was placed and cured. Once the attachment wells were prepared [figure 1(A) & 1(B)], Espe Filtek composite resin was applied in layers, with any excess resin carefully removed before curing. The resin was then photopolymerized with a light-curing unit (Elipar Visio II), which emitted a light intensity of 650 mW/cm² at a wavelength of 468 nm, as verified by a curing radiometer. The curing process involved irradiating the center (as incisal) of the pellets and the mesial and distal sides, with each side receiving 10 seconds of light exposure.

Three experimental groups were established for analysis: The uncured composite resin was directly analyzed for its degree of cure using MIR FTIR. Group I involved cured composite resin without the thermoformed sheet, which was also analyzed by MIR FTIR. Group II contained cured resin through a soft thermoformed sheet (Erkolen), and Group III included cured resin through a hard thermoformed sheet (Erkodur-al).

To assess the uncured composite, it was placed in the center of a disc in a micro-MIR FTIR apparatus for analysis of the degree of conversion. Cured composite [figure 2] samples were also placed in the MIR FTIR and examined. After curing, the samples were stored for 5 minutes at 37°C and 50% relative humidity. Following this period, the samples with both soft and hard templates were analyzed using micro multiple internal reflectance Fourier Transform Infrared Spectrometer (micro-MIR FTIR) [figure 3].

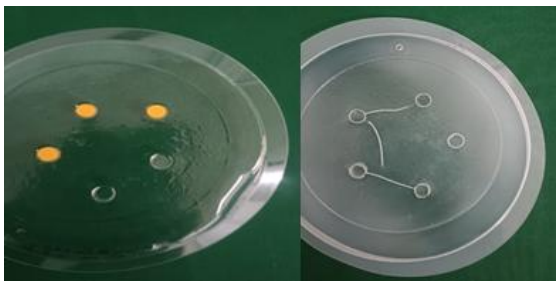


Fig 1: Attachment wells were prepared Hard (1) & Soft (2) templates.

Fig 2: Samples were analysed under micro-MIR FTIR.

Statistical analysis

A one-way analysis of variance (ANOVA) was conducted to assess the differences in the degree of conversion across the groups. The degree of conversion was found to be significantly different among the groups ($p < 0.05$). Post-hoc comparisons using a Tukey's test revealed that there were no statistically significant differences between the cured composite on the aligner and the composite side ($p = 0.126$), indicating a similar degree of conversion between these two conditions. However, significant differences were observed when comparing other groups.

III. Result

The degree of conversion varied significantly across different materials and surfaces. The hard sheet (Erkodur-al) on the composite side exhibited the highest degree of conversion (78.85 ± 8.99), followed by the hard sheet on the aligner side (73.12 ± 9.31). The soft sheet (Erkolen) on the composite side had a slightly lower degree of conversion (71.20 ± 9.15), while the soft sheet on the aligner side showed the lowest conversion (66.86 ± 13.84). The cured composite demonstrated the lowest overall degree of conversion (62.88 ± 3.01). Statistical analysis revealed no significant difference in the degree of conversion between the hard sheet on the aligner side and the hard sheet on the composite side ($p = 0.126$). However, significant differences were observed between other material groups. These findings suggest that the degree of conversion is influenced by both the type of material and the surface it is applied to.

Table 1: Comparsion between Degree of conversion Hard sheet (aligner side) and Degree of conversion soft sheet (aligner side)

Group	Hard Sheet	Soft sheet	P value
Degree of conversion - Aligner	**73.12 ± 9.31**	**66.86 ± 13.84**	**0.361**

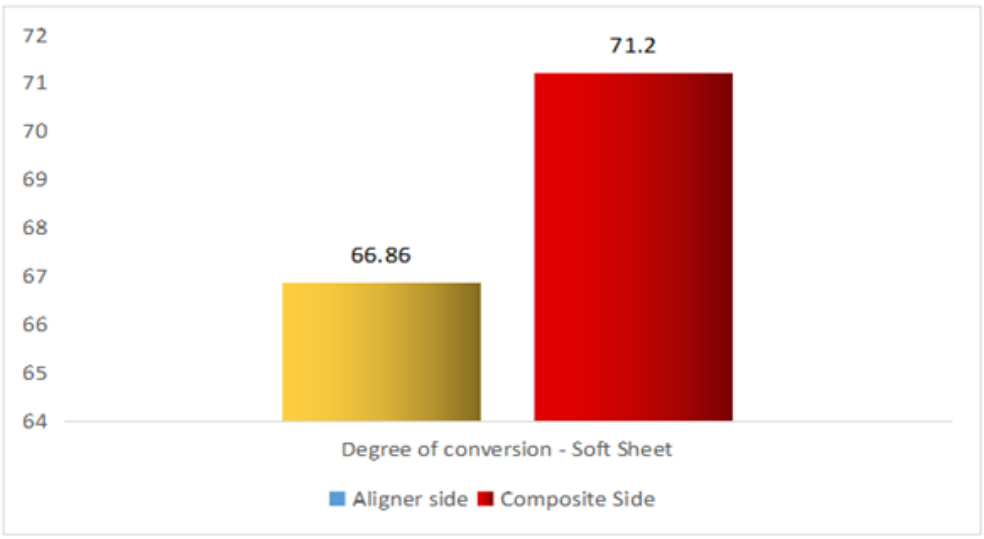
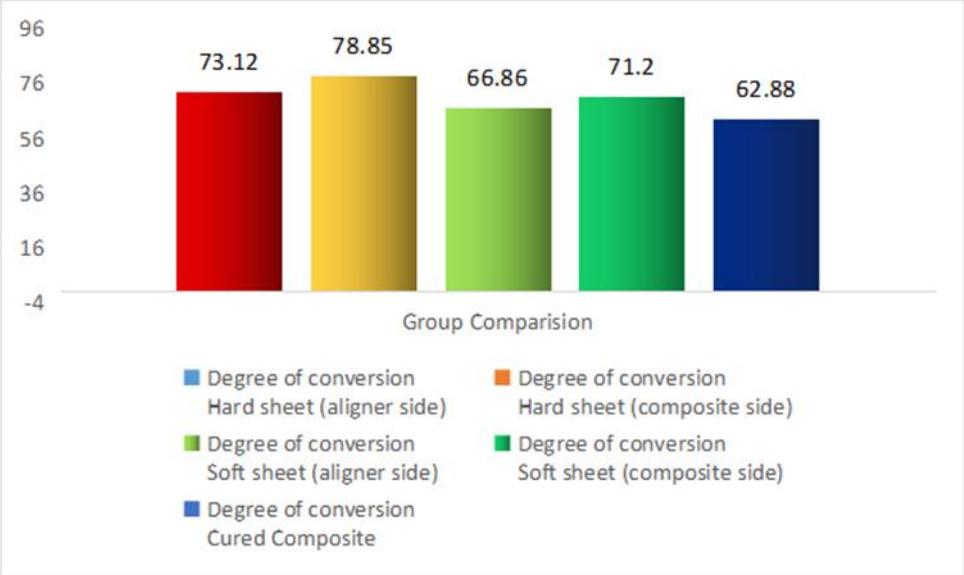


Table 5: Comparsion between all groups

Groups	Mean (S. D	P value
Degree of conversion Hard sheet (aligner side)	73.12 ± 9.31	0.126
Degree of conversion Hard sheet (composite side)	78.85 ± 8.99	
Degree of conversion Soft sheet (aligner side)	66.86 ± 13.84	
Degree of conversion Soft sheet (composite side)	71.20 ± 9.15	
Degree of conversion Cured Composite	62.88 ± 3.01	



IV. Discussion

Orthodontic Aligner Therapy (OAT) is rapidly transforming the field of dental and orthodontic care. Recent studies indicate that OAT now accounts for 30–45% of the average orthodontic practice's caseload. There is also a noticeable shift in patient preferences and their awareness of OAT [6]. One of the key benefits of OAT is its ability to provide consistent, gentle forces over an extended period, promoting better patient comfort. Additionally, aligner materials now feature improved qualities such as enhanced elasticity, chemical stability, and a more precise fit, making the treatment process more effective and comfortable [7]. Erkolen is commonly thermoformed to

produce a range of intra-oral appliances. Erkolen is a transparent, soft, and resilient thermoforming material composed of polyethylene (PE) with density of ISO 1183 0.924 g/cm³. For specific applications, the following thickness recommendations are suggested: 0.5 – 0.8 mm for copings, 1.0 mm for fluoride spacers, and 0.8 and 1.0 mm for temporary appliances (molding only) as well as bracket transfer/etching masks. And in this study, we use 0.6 thickness. As the technology has advanced, modern aligner systems have been developed to address more complex and severe malocclusions—conditions that were previously treated with traditional fixed orthodontics. While earlier orthodontic appliances had limitations, modern clear aligners offer significant improvements and better clinical outcomes [8]. In clinical practice, Erkodur can be more difficult to remove, whereas Erkolen allows for easier removal of the template. For enhanced operational efficiency, Erkolen is the preferred material. Composite attachments are a fundamental aspect of clear aligner therapy. These small, geometric buttons are essential for controlling tooth movements and providing anchorage, which in turn enhances aligner retention[9]. The material selection for these attachments is critical to ensure long-term stability and structural integrity. For example, Erkodur-al has been found to exhibit excellent stability. Clear aligner treatments rely on these attachments to maximize contact between the aligner and the tooth surface, improving the predictability of tooth movements[10]. Research has shown that 3M ESPE™ Filtek™ Z350 material demonstrates the least microleakage but is noted for having lower shear bond strength compared to other materials[11]. Hence, 3M ESPE™ Filtek™ Z350 was used in this study. Attachments are essential in clear aligner therapy, as they improve retention, assist in transmitting force to the teeth, and enable more advanced tooth movements, such as translation[12]. However, patient acceptance of numerous composite attachments, particularly their visibility, can pose a challenge. A high number or large attachments on the buccal surface can impact the invisibility of the aligners[13]. The thickness of the template is crucial for proper aligner seating and force transmission, but the transperancy of the sheet is also an important factor in determining the degree of cure of the composite. [14]. Micro-multiple internal reflection Fourier transform infrared spectroscopy has been proposed as an effective method for evaluating the C=C conversion of resin composites [15]. Hence, Fourier transform infrared spectrometer was used to assess the degree of cure of the composite. The face of the composite pellet (aligner side) cured using a hard sheet (Erkodur-al) exhibited the highest degree of conversion, followed by the base (composite side) of the composite pellet cured through the same hard sheet (Erkodur-al). The face of the composite pellet cured using a soft sheet (Erkolen) exhibited the lowest degree of conversion, followed by the base of the composite pellet cured through the same soft sheet (Erkolen). The degree of conversion of the composite pellet cured through a soft sheet (Erkolen) was lower compared to the composite pellet cured through a hard sheet (Erkodur-al). Thus, the higher degree of conversion achieved with the hard sheet (Erkodur-al) results from more uniform curing conditions,

better light transmission, and more consistent contact. The lower degree of conversion observed with the soft sheet (Erkolen) is likely due to its reduced transparency, which leads to uneven curing and poorer light transmission.

In clinical practice, Erkodur can be more difficult to remove, whereas Erkolen allows for easier removal of the template. For enhanced operational efficiency, Erkolen can be used since there is only minimum difference in the degree of cure of the composite cured using both the Erkodur-al and Erkolen.

V. Conclusion

The type of attachment template used in clear aligner therapy has a significant effect on the polymerization of composite resins. The use of hard thermoformed templates (e.g., Erkodur-al) leads to more complete polymerization and stronger attachments, while Erkolen may hinder the polymerization process. But also in clinical applications, Erkolen enables easier template removal, making it the preferred material for enhanced operational efficiency. This finding suggests that attachment template selection can be done based on the ease of use while providing adequate attachment strength. Since the degree of cure of the composite cured through the soft templates is in an acceptable range it can also be used as an attachment template based on the preference of the operator.

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