EVALUATION OF FRACTURE RESISTANCE AMONG TWO CERAMIC BRACKET SYSTEMS

Subaraman M[1], Dr. Dinesh Kumar*[2]
[1]Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai-600077
[2]Senior lecturer, Department of Pedodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Chennai-600077, Tamil Nadu, India.
Corresponding Author: Dr. Dinesh Kumar, Senior lecturer, Department of Pedodontics, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Chennai-600077, Tamil Nadu, India.
Mail ID- dineshkumarb.sdc@saveetha.com

ABSTRACT:
Introduction: With a trend towards orthodontic treatment with visually less noticeable appliances, the use of ceramic brackets has gained in popularity. The number of brands of ceramic brackets offered by manufacturers has increased significantly, a major drawback of ceramic brackets i.e. fracture of tie wings during treatment still persists. Ceramic brackets have a definite advantage over metal brackets in terms of decreased visibility and disadvantage as brittle. Shifting of atomic bonds and redistribution of stresses does not occur in ceramics whereas in metal brackets it is the reason for its toughness. To evaluate the fracture resistance between two groups of ceramic brackets. **Materials and methods:**Two separate groups of brackets named group A as the damon system and group B as orana system. Assessment of fracture resistance with instron universal testing machine. The obtained values were tabulated and statistical analysis was done using SPSS Software. **Results and discussion:** From the above results, Figure : 1 shows the mean value of fracture resistance of group A brackets as 9.91and for group B as 11.120. Here Group B- taken as standard to compare. Group A brackets show slight variations on individual fracture resistance while on calculating the mean, it is statistically insignificant. **Conclusion:** The present study confirms that the prepared ceramic bracket has similar fracture resistance to that of the standard bracket system. We checked only for the structural stability and assess its physical properties.
Key words: Ceramic brackets, Fracture resistance.

INTRODUCTION:

Orthodontic treatment has witnessed remarkable advancements, not only in terms of aesthetics but also in the quality and longevity of the outcomes. The selection of bracket systems is a critical aspect of orthodontic practice, significantly impacting the success and durability of treatment. Ceramic brackets have gained prominence as a cosmetically appealing alternative to traditional metal brackets. Their aesthetic advantages have made them a popular choice among patients seeking less conspicuous orthodontic solutions(1). However, concerns regarding the fracture

resistance of ceramic brackets have emerged as a critical issue. The use of ceramic brackets has grown in favor as orthodontic treatment with less obvious appliances has become more common. Despite the fact that manufacturers now provide a far greater variety of ceramic bracket brands, one of their main drawbacks is the possibility of tie wing fracture during treatment remains(2).

In terms of reduced visibility, ceramic brackets clearly outperform metal brackets. However, ceramic brackets have a number of significant drawbacks, including being fragile. The total loading energy required to break a material is its fracture toughness. Ceramics have fracture toughness values that are 20 to 40 times lower than those of stainless steel. When a metal is under stress, the grain boundaries move, redistributing and releasing the stress(3). Ceramics are more brittle and fracture more quickly because this redistribution of stresses and shifting of atomic bonds do not occur in them. Cracks, impurities, porosity, and the presence of localized Lessening the fracture resistance of ceramic brackets can be caused by pressures and scratches, inadequate heat treatment, inappropriate design, and improper material. Therefore, distinct brands of ceramic brackets made by various manufacturers, rather than materials, need to be compared in order to assess the fracture resistance of ceramic brackets(4).
Although aluminum oxide makes up all ceramic brackets, there are two varieties of ceramic brackets: monocrystalline and polycrystalline aluminum oxide. The translucency of a monocrystalline and polycrystalline ceramic bracket is the primary optical distinction. The material and manufacturing process have an impact on the physical characteristics of ceramic orthodontic brackets(5). This study aims to assess and compare the fracture resistance of two specific ceramic bracket systems, exploring the factors contributing to their strength and potential limitations. Understanding the fracture resistance of these bracket systems is crucial for orthodontists and patients alike, as it can influence the choice of bracket type and ultimately impact the success and longevity of orthodontic treatment. In this context, this research delves into the mechanics, materials, and design of ceramic brackets to shed light on their fracture resistance, providing valuable insights for orthodontic practitioners and patients seeking the most appropriate treatment options.

MATERIALS AND METHODS:

Two different brands of brackets were tested. Four brackets were damon brand and four brackets were orana was tested in this study. Both anterior and posterior brackets were tested for all mesioincisal wings. An instron universal testing machine was used to apply a vertical force on the mesial incisal wings of each bracket. Testing point was fitted onto the output of an instron machine. This testing point applied a vertical force to the middle of the facial surface of the mesial incisal tie wing of the orthodontic brackets. The brackets were positioned so that the testing point made contact with the tie wing midway through both the bracket's length and mesiodistal width. The testing point sank at a pace of.10"/min after the bracket was positioned beneath it in the proper manner. This speed was chosen to be as quick as feasible while maintaining the ability to precisely read the force value from the digital display of the Instron machine. The force was digitally read out by the Instron machine as it grew until the tie wing broke. The fracture strength

was measured at the location of the tie wing fracture. A small amount of testing point deformation was observed following many dozen bracket tests in a pilot study evaluating this apparatus.

Figure: 1 Group A (Damon)

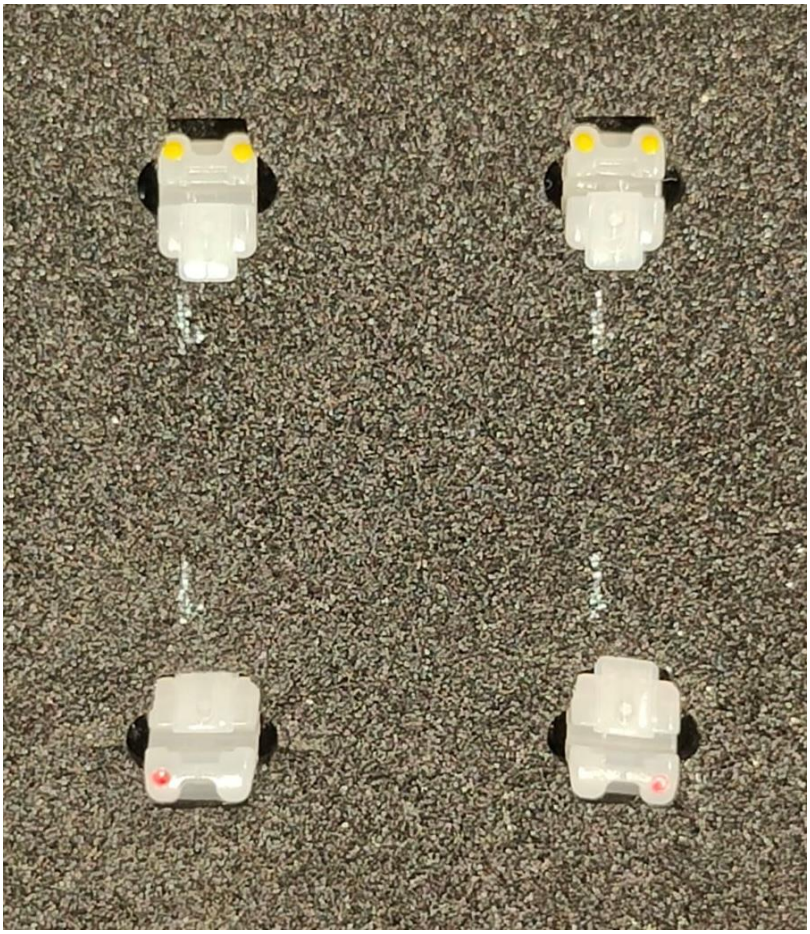

Figure:2 Group B(Orana)

Figure: 3 instron universal testing machine

RESULTS:

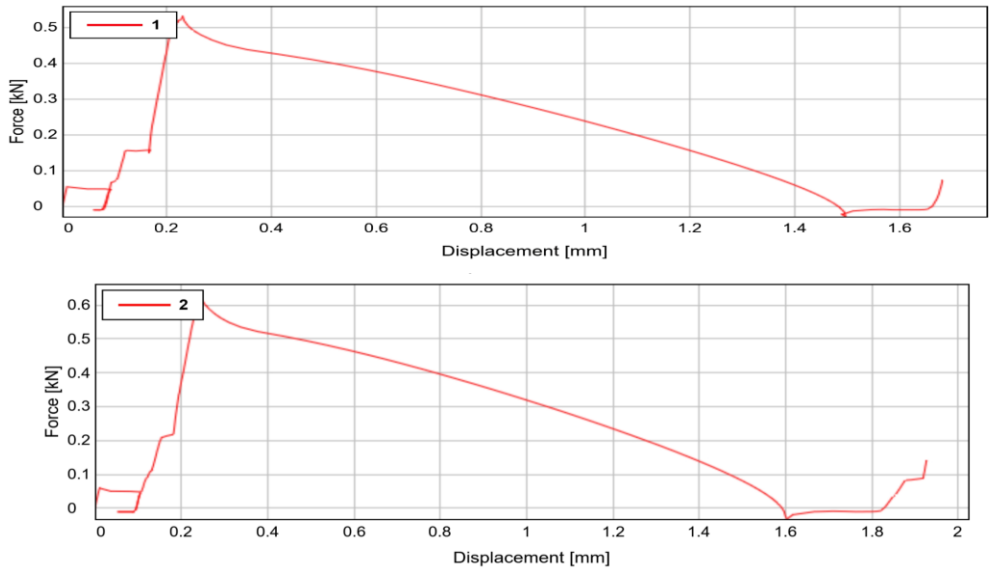

Figure: 4 represents the graph of fracture resistance.

	MEAN OF MPa	STANDARD DEVIATION OF MPa
GROUP A	9.910	1.11
GROUP B	11.120	1.6

Figure: 5 Represents the mean and standard deviation of MPa

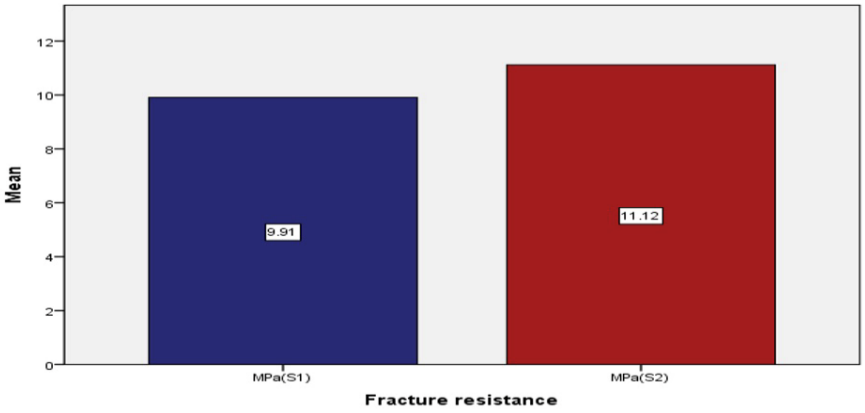

Figure: 6 Represents the bar chart of mean MPa

The fragility of ceramic brackets, particularly the tie wings, is a well-known limitation in their clinical use. These brackets, although continuously improving in terms of material strength, remain prone to fractures, especially at the tie wing areas, which are subjected to considerable force during orthodontic treatment. Previous research has highlighted that these regions are most vulnerable to breakage, and any failure in these critical components can compromise the effectiveness and longevity of the braces. The results, as represented in Figure 1, show the mean fracture resistance values for two groups of brackets: Group A and Group B. Group A, with a mean fracture resistance of 9.91 N, demonstrates a slightly lower fracture resistance compared to Group B, which has a mean value of 11.12 N. Group B, as the standard in this comparison, serves as the reference for evaluating the relative performance of Group A brackets. Despite the slight difference in fracture resistance between the two groups, it is important to note that the variations in individual fracture resistance values within Group A are statistically insignificant. This suggests that while Group A shows minor differences in performance, these differences do not reach a level of significance that would imply a meaningful clinical distinction. In other words, the variation in fracture resistance observed in Group A could likely be attributed to random factors or inherent material inconsistencies, rather than any substantial difference in the quality or durability of the brackets.

Thus, although Group B shows a marginally higher mean fracture resistance, the results indicate that the ceramic brackets in Group A are generally consistent in terms of performance, and the slight differences in fracture resistance are not statistically significant. This suggests that while Group B may offer slightly improved fracture resistance, the clinical implication of this difference is minimal, and Group A brackets are likely to perform adequately in most clinical settings.

DISCUSSION:

Variations in the strength of ceramic brackets, both across different brands and within the same brand, can be attributed to several factors inherent in the design and manufacturing processes. The structural integrity of ceramic brackets is highly influenced by their material composition,

processing methods, and the final finishing techniques(6). Differences in these processes can lead to significant variations in the mechanical properties of the brackets, particularly their fracture resistance. Studies have shown that factors such as porosity, impurity inclusion, fractures, localized stresses, scratches, insufficient heat treatment, and poor design and material choice are all potential causes of reduced fracture resistance in ceramic brackets(7). These issues can weaken the overall structure of the brackets and make them more susceptible to failure under stress, especially in high-stress areas such as the tie wings.

One of the key findings in this area is that internal manufacturing errors and machining interference account for a substantial portion of the fractures observed in ceramic brackets. These two factors were responsible for approximately 90% of the ceramic fractures documented in previous studies. This indicates that problems arising during the production phase, such as errors in machining or inconsistent internal structure, can severely compromise the mechanical strength of ceramic brackets. In addition, different manufacturers employ varied approaches to critical processes like heat treatment, surface finishing, and the choice of grain size in the ceramic material, all of which can impact the final product's durability (8). These discrepancies further explain why certain brands may perform better or worse in terms of fracture resistance.

Moreover, the shape and design of the ceramic bracket can influence its fracture resistance. Research has demonstrated that brackets with smoother, more rounded shapes tend to exhibit higher fracture strengths when subjected to torsional and tilting stresses. This finding suggests that the geometry of the bracket plays a role in distributing stresses more evenly across the structure, thereby reducing the likelihood of localized failures. The design and shape of the brackets, combined with manufacturing techniques, can contribute significantly to their overall performance. Consequently, variations in bracket design and production processes across brands may explain the observed differences in fracture resistance (9,10). These factors make it crucial for clinicians to consider the specific design features and manufacturing methods of the brackets they choose to use in their practice.

Given the considerable variability in the fracture resistance of ceramic brackets, it is important for clinicians to be aware of these differences when selecting brackets for clinical use. Even within a single brand, there can be considerable variation in the durability of the ceramic brackets, which may affect the clinical outcomes of orthodontic treatment. Understanding the potential for fracture and the factors that influence it can help clinicians make more informed decisions about bracket selection. This study's findings provide valuable data that can guide practitioners in choosing ceramic brackets with the appropriate fracture resistance, particularly in high-stress areas such as the tie wings, thereby improving the overall success and longevity of orthodontic treatments (11,12)

CONCLUSION: The present study confirms that the prepared ceramic bracket has similar fracture resistance to that of the standard bracket system.

ACKNOWLEDGEMENT

We thank Saveetha Dental College and Hospitals for providing us the support to conduct the study.

CONFLICT OF INTEREST

The author declares that there was no conflict of interest in the present study.

SOURCE OF FUNDING

The present study is funded by the following

- Saveetha Dental College and Hospitals , Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai.
- Anbu Offset Achagam

REFERENCE:

1. AlBadr AH, Talic NF. Testing the tensile fracture strength tie-wings of different orthodontic ceramic bracket using an Instron machine. Saudi Dent J. 2023 Dec;35(8):1048–52.
2. Hillam RH. Torsional Fracture Strength of Nine Ceramic Orthodontic Brackets: An in Vitro Study. 1990. 292 p.
3. Nawrocka A, Nowak J, Sauro S, Hardan L, Bourgi R, Lukomska-Szymanska M. Shear Bond Strength of Metal and Ceramic Brackets Depending on Etching Protocol in Direct Bonding Technique. Materials (Basel) [Internet]. 2023 Oct 15;16(20). Available from: http://dx.doi.org/10.3390/ma16206697
4. Kate James M, Yu Q, Mon H, Xu X, Blanchard A, Armbruster P, et al. Comparison of Tie Wing Fracture Resistance of Differing Ceramic Brackets. Turk J Orthod. 2022 Dec;35(4):255–9.
5. Khan H. Orthodontic Brackets: Selection, Placement and Debonding. CreateSpace; 2015. 284 p.
6. Karamouzos A, Athanasiou AE, Papadopoulos MA. Clinical characteristics and properties of ceramic brackets: A comprehensive review. Am J Orthod Dentofacial Orthop. 1997 Jul;112(1):34–40.
7. Pawinru AS, Hidayati N, Erwansyah E, Habar EH, Ranggang BM, Suronoto S. A Comparison of Adhesion to Metal and Ceramic Brackets with Coated and Uncoated Nickel Titanium Orthodontic Archwires: An In Vitro Study. Acta Med Philipp. 2024 Dec 13;58(22):106–10.
8. El Arabi MA, Abu Shamaa N, Elkilani NS, Taha RM. Microleakage under metal and ceramic brackets after acid etch or laser surface treatment before bonding: An in vitro study. J Orthod. 2025 Jan 3;14653125241309654.
9. Lenin A, Anbarasu P, Kumar SS, Narayanan A, Dhingra R, Ramesh B. Comparison of Microleakage and Bond Strength in Metal and Ceramic Brackets Cured by Conventional and Transillumination Methods: An Evaluation. Int J Clin Pediatr Dent. 2024 Sep;17(9):999–1003.
10. Hamdan AH, Saleah SA, Seong D, Ravichandran NK, Wijesinghe RE, Han S, et al. Three-Dimensional Assessment of Dental Enamel Microcrack Progression After Orthodontic Bracket Debonding Using Optical Coherence Tomography. J Funct Biomater [Internet]. 2024 Dec 30;16(1). Available from: http://dx.doi.org/10.3390/jfb16010007
11. Ramasundaram S, Srinivasan D, Ravi K, Devasahayam D. Comparing the mechanical

properties of the polymer orthodontic bracket materials with the conventional orthodontic bracket materials: A systematic review. Dent Res J (Isfahan). 2024 Nov 21;21:59.

12. Zhang OL, Yin IX, Yu OY, Luk K, Niu JY, Chu CH. Advanced Lasers and Their Applications in Dentistry. Dent J (Basel) [Internet]. 2025 Jan 16;13(1). Available from: http://dx.doi.org/10.3390/dj13010037