ENGINEERING

McMaster University

Project 2 – Independent Research Summary

Orthodontics – Metal brackets of dental braces

ENGINEER 1P13 – Integrated Cornerstone Design Projects

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Executive Summary

Orthodontic treatment involves attaching orthodontic brackets to the teeth in order to move them into a straighter position [1]. The metal orthodontic brackets are important because they hold the metal archwire in place, which forms a fixed brace which straightens teeth by applying a light continuous force [2]. A modern orthodontic bracket is bonded directly to the tooth using dental cement [2], then the metal archwire is then guided through the slots in each of the metal brackets [2]. These brackets are typically composed of stainless steel, titanium and titanium alloys, or cobalt-chromium alloys [1].

References

[1] "Orthodontic Brackets (Braces): How do They Work? | ART Orthodontics Davie FL," Dec. 19, 2019. https://www.artorthodontics.com/2019/12/orthodontic-brackets-braces-how-do-they-work/ (accessed Dec. 09, 2020).
[2] "Ansys Granta EduPack software", Granta Design Limited, Cambridge, UK, 2020 (www.grantadesign.com).

Annotated Bibliography

[1] T. Eliades, "Orthodontic materials research and applications: Part 2. Current status and projected future developments in materials and biocompatibility," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 131, no. 2, pp. 253–262, Feb. 2007, doi: 10.1016/j.ajodo.2005.12.029.

The typical composition of orthodontic metallic brackets is usually one of a few usual suspects, namely stainless steel and its alloys, or titanium and titanium alloys. These materials are good choices for brackets as they all share the properties of having high strength and corrosion resistance, which are the two most desirable traits for an orthodontic bracket. Different combinations of material compositions each yield different hardness and galvanic corrosion resistance, so as of now there is no definitive optimal metallic alloy for composing these brackets. Another consideration to make is the allergenicity of some nickel alloys, even despite the low percentage of reactions in patients. New brackets are sometimes composed of plastics or ceramics for a more aesthetically pleasing look but are somewhat problematic as there can be deformation in plastics and cracking in ceramics. Even after reinforcement they are still softer and more prone to wear than traditional brackets.

[2] O. Keith, S. P. Jones, and E. H. Davies, "The Influence of Bracket Material, Ligation Force and Wear on Frictional Resistance of Orthodontic Brackets," *British Journal of Orthodontics*, vol. 20, no. 2, pp. 109–115, May 1993, doi: 10.1179/bjo.20.2.109.

The frictional forces that exist between orthodontic brackets and archwires are a problem for tooth movement because it can restrict the movement of the tooth or apply forces which cause the tooth to move in an undesired direction. The frictional coefficient in these situations is dependant on the texture, hardness, and temperature of the opposing surfaces, therefore the selected material of the bracket plays a large role in how much friction exists. In a comparison between two primary types of brackets composed of different types of stainless steels and ceramics, the amount of planar static frictional resistance was determined to generally be higher with the ceramic brackets than the stainless steel brackets. Also, for each combination of brackets and archwires, the frictional resistance increased proportionally with the force of ligation for that combination. Finally, the ceramic brackets produced abrasive wear on the archwire while the stainless steel brackets did not.

[3] D. Birnie, "Ceramic Brackets," *British Journal of Orthodontics*, vol. 17, no. 1, pp. 71–75, Feb. 1990, doi: 10.1179/bjo.17.1.71.

Because the aesthetics of orthodontic braces can be a concern of many patients, aesthetically pleasing as well as technically performant brackets are being developed. The material chosen to make these brackets is important to these functions. The brackets must be able to sufficiently adhere to the teeth, be strong enough to withstand prolonged torsional forces without deforming, be resistant to corrosion, and be translucent. Recently, brackets made of ceramic, sometimes reinforced with plastic, have seen more widespread use, but their structural integrity in the long-term relative to steels has not been sufficiently studied. Ceramics are useful in this application because of their ability to be translucent and their chemical inertness, but they are not as good as some steels in terms of how strong they are and how prone to cracking they are due to their brittleness. Currently, ceramic brackets only beat traditional brackets in terms of aesthetics.

Additional References

[1] E. Morina, T. Eliades, N. Pandis, A. Jäger, and C. Bourauel, "Torque expression of self-ligating brackets compared with conventional metallic, ceramic, and plastic brackets," *European Journal of Orthodontics*, vol. 30, no. 3, pp. 233–238, Jun. 2008, doi: 10.1093/ejo/cjn005.

[2] V. Cacciafesta, M. F. Sfondrini, A. Ricciardi, A. Scribante, C. Klersy, and F. Auricchio, "Evaluation of friction of stainless steel and esthetic self-ligating brackets in various bracket-archwire combinations," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 124, no. 4, pp. 395–402, Oct. 2003, doi: 10.1016/S0889-5406(03)00504-3.

[3] A. Karamouzos, A. E. Athanasiou, and M. A. Papadopoulos, "Clinical characteristics and properties of ceramic brackets: A comprehensive review," *American Journal of Orthodontics and Dentofacial Orthopedics*, vol. 112, no. 1, pp. 34–40, Jul. 1997, doi: 10.1016/S0889-5406(97)70271-3.