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## **Project 2 – Independent Research Summary**

### **Metal Brackets of Dental Braces**

*ENGINEER 1P13 – Integrated Cornerstone Design Projects*

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Submitted: December 10, 2020

## ***Executive Summary***

Metal brackets are one of the main components of dental braces. These brackets are bonded to the tooth using a special dental cement or onto a metal orthodontic band (around the molars). The purpose of the brackets is to hold the metal wire (that moves the teeth) in place. The frequently used materials for these metal brackets include stainless steel, titanium, titanium alloys, and cobalt-chromium alloys. These materials are often used because the metal brackets must be strong and hard, corrosion resistant, minimize friction, avoid plaque deposition, and biocompatible.

## ***References***

- [1] V. Korniienko, O. Oleshko, Y. Husak, V. Deineka, V. Holubnychy, O. Mishchenko, A. Kazek-Kęsik, A. Jakóbi-Kolon, R. Pshenychnyi, K. Leśniak-Ziółkowska, O. Kalinkevich, A. Kalinkevich, M. Pisarek, W. Simka, and M. Pogorielov, "Formation of a Bacteriostatic Surface on ZrNb Alloy via Anodization in a Solution Containing Cu Nanoparticles," *MDPI*, vol. 13(18), 04-Sep-2020. [Online]. Available: <https://www.mdpi.com/1996-1944/13/18/3913>. [Accessed: Dec. 7, 2020].
- [2] B. S. Kumar, S. Miryala, K. K. Kumar, K. Shameem, and R. R. Regalla, "Comparative Evaluation of Friction Resistance of Titanium, Stainless Steel, Ceramic and Ceramic with Metal Insert Brackets with Varying Dimensions of Stainless Steel Wire: An In vitro Multi-center Study," *Journal of international oral health*, vol. 6(5), pg. 66-71, *JIOH*, Sep-2014. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4229833/>. [Accessed: Dec. 7, 2020].
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## ***Annotated Bibliography***

- [1] V. Korniienko, O. Oleshko, Y. Husak, V. Deineka, V. Holubnychy, O. Mishchenko, A. Kazek-Kęsik, A. Jakóbi-Kolon, R. Pshenychnyi, K. Leśniak-Ziółkowska, O. Kalinkevich, A. Kalinkevich, M. Pisarek, W. Simka, and M. Pogorielov, "Formation of a Bacteriostatic Surface on ZrNb Alloy via Anodization in a Solution Containing Cu Nanoparticles," *MDPI*, vol. 13(18), 04-Sep-2020. [Online]. Available: <https://www.mdpi.com/1996-1944/13/18/3913>. [Accessed: Dec. 7, 2020].

For the last 50 years, titanium has been used as one of the most common dental implants worldwide due to some of its extraordinary properties, but some of these titanium alloys have caused implant failures [1]. To have any sort of metal implant, it is crucial that the material must have an excellent corrosion resistance, high strength, high biocompatibility, antibacterial, etc., however it is very difficult to find a material which contains all these qualities [1]. In this study, plasma electrolytic oxidation coatings were integrated with copper nanoparticles, which are a promising alternative due to low cell toxicity, to assess the biocompatibility and antibacterial properties. It was concluded that the plasma electrolytic oxidation on a Zirconium Niobium (ZrNb) alloy in a Ca-P solution with copper nanoparticles formed a stable ceramic layer and was recommended for further investigation [1].

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Varying Dimensions of Stainless Steel Wire: An In vitro Multi-center Study,” *Journal of international oral health*, vol. 6(5), pg. 66-71, *JIOH*, Sep-2014. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4229833/>. [Accessed: Dec. 7, 2020].

Two of the most crucial parts of orthodontics are good biocompatibility and low friction, but from the numerous bracket combinations (e.g. titanium, stainless steel, ceramics), it is difficult to determine which is the best [2]. Through the study “Comparative evaluation of friction resistance of titanium, stainless steel, ceramic and ceramic with metal insert brackets with varying dimensions of stainless-steel wire”, it was revealed that titanium had the least resistance when pushed on by a significant force from the wire. The stainless-steel bracket had displayed higher static friction as the wire size increased, but for all the wires that were not thick, the static friction was lower than titanium’s. Although the ceramic brackets had a significantly lower static friction compared to titanium, it was proven that the best bracket would contain the rough surface texture from the titanium bracket and stainless-steel ligature wire, as it would reduce friction [2].

- [3] O. Mishchenko, O. Ovchynnykov, O. Kapustian, and M. Pogorielov, “New Zr-Ti-Nb Alloy for Medical Application: Development, Chemical and Mechanical Properties, and Biocompatibility,” *MDPI*, vol. 13(6), 13-Mar-2020. [Online]. Available: <https://www.mdpi.com/1996-1944/13/6/1306/htm>. [Accessed: Dec. 7, 2020].

Mechanical biocompatibilities, along with high strength and low density, is a critical factor when considering orthopedics and dental implants [3]. Titanium based alloys have a high Young’s Modulus, that can cause stress-shielding syndrome and late postoperative complications, which is why a titanium alloy with a low Young’s Modulus is needed [3]. Unfortunately, the production would be very costly and require complex metallurgical solutions [3]. Due to this, a new research to develop a Zirconium Titanium Niobium system (Zr-Ti-Nb) with a low Young’s Modulus and a 60-19-21% mass of Zr-Ti-Nb is being pursued. Since these different materials would not affect the chemical compound and mechanical properties, it would be a more suitable replacement to decrease the price.

### ***Additional References***

- [1] O. Oleshko, I. Liubchak, Y. Husak, V. Korniienko, A. Yusupova, T. Oleshko, R. Banasiuk, M. Szkodo, I. Matros-Taranets, A. Kazek-Kęsik, W. Simka, and M. Pogorielov, “In Vitro Biological Characterization of Silver-Doped Anodic Oxide Coating on Titanium,” *MDPI*, vol. 13(19), 30-Sep-2020. [Online]. Available: <https://www.mdpi.com/1996-1944/13/19/4359/htm>. [Accessed: Dec. 7, 2020].
- [2] A. Kumar, A. Khanam, and H. Ghafoor, “Effects of intraoral aging of arch-wires on frictional forces: An *ex vivo* study,” *Journal of orthodontic science*, vol. 5(4), pg. 109-116, 2016. [Online]. Available: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5084471/>. [Accessed: Dec. 7, 2020].
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