Lock Washer for Dental Implant-Supported Restorations

University of Wisconsin-Madison, Department of Biomedical Engineering
Advisors: Dr. John Puccinelli and Tyler Ross Client: Dr. Donald Tipple
Authors: Maggie McDevitt, Isabelle Peters, Caroline Davis, Aaron Marattil, Jacki Szelagowski, Kennedy Young

Background & Motivation

- Background

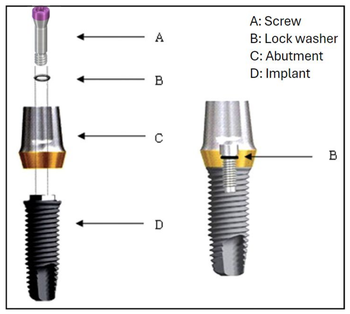


Figure 1: *Fixture-abutment complex with washer* [1]

  - Five percent of dental implants fail [2]
    - Typically titanium, a titanium alloy, or zirconia are used due to biocompatibility
    - Implant should last at least 15 years [3]

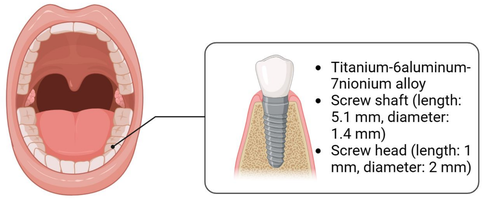


Figure 2: *Location of Implant and Screw Specifications*

  - Lock Washer
    - Provides tensile force in opposite directions, resisting vibration and torque
    - Different types: split, conical spring, internal-external tooth, flat, etc.
- Motivation
  - Minimize frequency of patients experiencing screw loosening
  - Determine if a lock washer on the screw will keep the abutment tight and prevent it from loosening

Design Criteria

- Final material must be biocompatible
- Prevent adverse interactions between different types of metals within the existing mechanism (titanium alloy preferable)
- Torque to remove the screw must be greater than the 35 Ncm used to initially tighten the screw

Preliminary Work

- The initial design idea was to use a lock washer inside the abutment as shown in Figure 1
  - Received quotes from companies that 3D printed in titanium for fabrication (roughly $60 per washer)
  - Tested the design in Solidworks by applying forces, fixing a side, and measuring the displacement (Figure 3)
  - Tested using a standard dental screw within the implant mechanism
  - Split lock washer showed substantial deformation, 10 times larger than its original split
  - Deformation resulted from the tapered screw head causing the washer to expand (Figure 4)

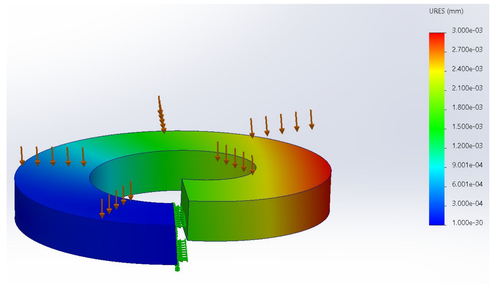


Figure 3: *Split lock washer testing in Solidworks*

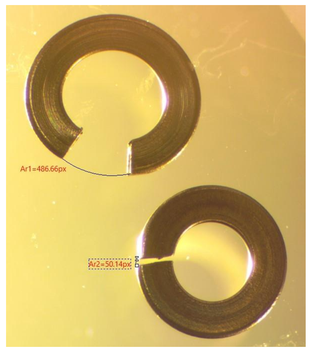


Figure 4: *Deformed split lock washer from tapered screw head next to unused split lock washer*

Final Design

- Split lock washer placed below the abutment, around the screw, and above the implant

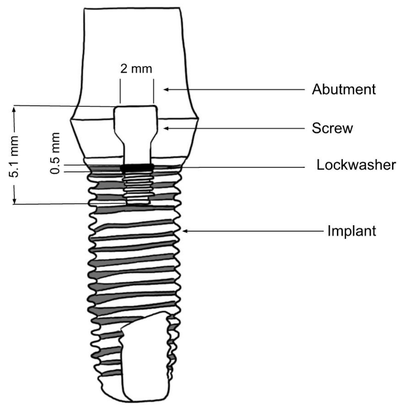


Figure 5: *Final Design of fixture-abutment complex with washer*

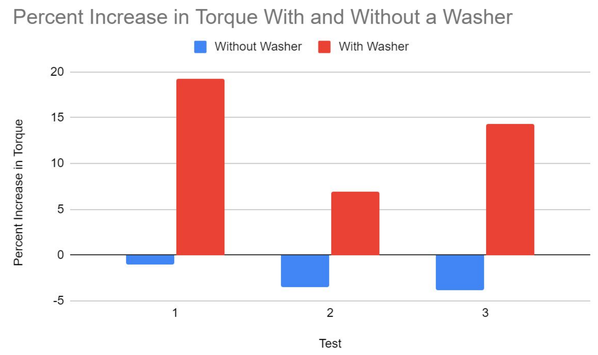
Testing

- Stainless steel screws scaled to 8.865x larger than those used in the mechanism, and washers scaled accordingly
- Control:
  - A screw was torqued into a piece of plastic with a standard washer under the screw head at ~200 N-cm
  - After five minutes, the screw was removed and the torque required to remove was recorded
- Experimental:
  - The same process was then replicated with a split lock washer under the regular washer (Figure 6)
  - Simulates the split lock washer pushing against the abutment (can create friction)

Figure 6: *Testing with a standard washer above the split lock washer*

Figure 7: *Using the torque tester*

Results



- Split lock washer greatly increased the strength of the mechanism
- An additional trial was ran where the screw was left for 10 minutes
  - 35.72% increase in torque
  - Slight discrepancies could be due to over tightening (loses locking ability and acts as flat washer) [4]

Future Work

- Fabricate washer with desired materials
- Examine long term effects of a washer within the implant system
- Alter screw design so implantation procedure is easier for dentist
- Reduces potential for mistakes leading to more secure implants

Acknowledgements

- Dr. John Puccinelli
- Tyler Ross
- Jesse Darley
- Joy Bowe
- UW-Madison TEAMLab
- UW-Madison BME Department
- UW-Madison MakerSpace

References

[1] O. Jamiyandorj, S. Kim, J.-S. Shim, and K.-W. Lee, "Effect of Using a Titanium Washer on the Removal Torque of an Abutment Screw in the External Connection Type of Dental Implant," *Implant Dent.*, vol. 21, no. 2, p. 156, Apr. 2012, doi: 10.1097/ID.0b013e31824a02b9.
[2] "Glossary of Dental Clinical Terms | American Dental Association." Accessed: Oct. 10, 2023. [Online]. Available: https://www.ada.org/publications/cdt/glossary-of-dental-clinical-terms
[3] "How Long Do Dental Implants Last, What Impacts the Duration?," Healthline. Accessed: Sep. 21, 2023. [Online]. Available: https://www.healthline.com/health/dental-and-oral-health/how-long-do-dental-implants-last
[4] R. T. Barrett, "Fastener Design Manual." Mar. 01, 1990. Accessed: Dec. 06, 2023. [Online]. Available: https://ntrs.nasa.gov/citations/19900009424