Executive Summary: Tong BME Design Award, BME 402

Approximating Surface Matrix Band for Dentists to Use in Patients

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It was estimated by the CDC in 2019 that the average American has three dental fillings, while one in four Americans have eleven or more fillings, and about one-third of adults have untreated dental cavities that require fillings. According to Grand View Research in 2019, the global dental fillings market size was estimated at USD 5.57 billion with an expected compounded annual growth rate of 7.2% from 2019 to 2026. The main driving factor of the growing market is both the increasing population and prevalence of dental caries.

Matrix bands are a commonly used dental tool which assist dentists by supporting the outer contour of a decayed tooth. They provide support, shape and contour for replacement filling material while protecting surrounding tissues. Current matrix bands are either circumferential bands, which wrap around the entire tooth, or sectional bands, that only wrap partially around the tooth. During typical filling procedures for cavities between two adjacent teeth, dentists must fill each tooth individually. This is a tedious procedure as each matrix band must be shaped, placed and secured with dental wedges and rings for each tooth separately, as the typical spacing between teeth is too small to fit two individual matrix bands between them. A new dental matrix band design is desired to alleviate the need to repeatedly place bands.

Our matrix band design can support the simultaneous filing of two adjacent teeth while only setting the matrix band once. It mimics two adjacent sectional matrix bands, with the thickness of the band kept to a maximum of 0.002” when folded once, to ensure a proper tooth contact is maintained post-filling. This design also incorporates a holed tab for easy placement and removal as well as a space in the lower interproximal area to allow the use of a wedge. The convex geometry of the bottom edge provides further protection and support in the gingival region. The dimensions and geometry of the wings and tab provide compatibility with existing tools for setting and securing the band in the proper space and depth. These functions are all met without being harmful to the existing tissues of the mouth due to rounded edges and inert material selection. Novel aspects of this design include its simplicity, compatibility with existing tools, and ability to serve interproximal tooth restoration.

The design was validated via mechanical testing to ensure the bands maintained proper tensile strength and elastic modulus through manufacturing. This involved simulating force loads and doing physical tensile tests to create stress strain curves on our prototypes. The 1008 stainless steel used in early prototypes showed an elastic modulus of 672.7 GPa while the market available bands had a 162.8 GPa modulus, suggesting the 1008 material requires more force to be displaced than market available bands. Data obtained from testing 316 stainless steel in our prototype appeared to have a more similar Young's Modulus although testing is still in process for this alloy. There was also a qualitative aspect to our testing via practicing dentists. They were able to use the device on mouth models to evaluate improvements over conventional methods. The bands are currently being evaluated based on criteria including: ease of placement, proper function, and fabrication integrity, all ranked on a scale from 1-5 for an evaluation matrix.

If this design were to be commercialized, it would fill a large market gap, providing a much more efficient way to fill interproximal cavities. With millions of cavities being filled each year, and many of them afflicting adjacent teeth, we would expect our design to be the matrix band of choice for these interproximal cavities for most dentists. Not only would it make the procedure easier and more efficient for the dentist, but also less costly and would maximize the amount of time dentists have to care for other patients.