Executive Summary: BME Design Excellence Award, BME 301

Graduated Bowman's Probe for Nasolacrimal Duct Obstruction

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The usage of Bowman's probes is commonplace in the treatment of Nasolacrimal Duct Obstruction. Doctors use Bowman's probes to measure the depth of obstructions in the nasolacrimal duct and provide treatment plans. However, without distinguishable graduation markings, surgeons have to estimate insertion depths. The design of a graduated Bowman's probe is essential in order to reduce measurement inaccuracies and increase treatment plan accuracy. While graduated Bowman probes have been implemented in laboratory settings, such as at Pennsylvania State University, the prototypes have not been introduced into clinical practice. Additionally, current medical device companies prevalent in the Bowman probe market have yet to implement graduated Bowman probes into their market line.

Each graduated Bowman probe consists of hash marks every 2.5 millimeters over a total graduated length of 35 millimeters. The markings were produced using a 200-watt laser, creating consistent, repeatable, precise, and permanent markings on the stainless steel surface. The selected spacing represents the smallest uniform interval achievable before laser instability. During fabrication, a steel fixture was used to align each probe in the same position to ensure consistent and uniform alignment under the laser's focal point. The final design is unlike any existing Bowman probe on the market and enhances the precision of current ophthalmological assessment within the nasolacrimal canal.

To support integration of the probes into ophthalmological practice at the UW Hospital, it was necessary to demonstrate that laser-induced graduation does not adversely affect probe performance, particularly with respect to patient safety. Several sets of clinical-grade graduated probes were experimentally compared with unmodified probes through sterilization endurance, synthetic lacrimal fluid biocompatibility, and agar-gelatin phantom tissue pull testing procedures. The experiments looked to observe the interaction between the environment and the probes, with a specific emphasis on identifying increased degradatory or abrasive effects as a result of the graduation. Each test indicated no statistical distinction between the two probe types, demonstrating their theoretical implementation. The probes were further validated by the client through a cadaveric proof-of-concept assessment, supporting their integration into standard clinical practice.

The graduated Bowman's probe was designed to improve depth measurement accuracy while preserving the original probe's form and function. The addition of 2.5 mm laser markings using a specialized industrial-grade laser enhances the precision of graduation to the micrometer level, increasing assessment accuracy and reducing reliance on estimation. Because the process only temporarily modifies the chromium oxide surface layer, the probe maintains its biocompatibility, with testing showing no increased degradation. The design is fully compatible with standard sterilization procedures, as repeated autoclave cycles resulted in no damage or fading of markings. Fixture-guided laser processing supports consistent manufacturing, while the unchanged design allows seamless integration into existing practice. Improved measurement accuracy contributes to more effective treatment of nasolacrimal duct obstructions, reducing procedure time and the likelihood of repeat interventions. It remains cost-effective through reusability and compatibility with existing hospital practices, while scalable manufacturing enables broad adoption across clinical systems.