Laser System Mimics Traditional Dentist's Drill

Written by John Wingerd
7 December 2015

After decades of promise and hype, but very limited market uptake, laser systems for dentistry are finally taking off. One of the leading products is the Solea from Convergent Dental, which provides a superior alternative to the mechanical drill, plus the flexibility for several soft tissue procedures, including wound sealing, and even cutting/ osseous tissue (bone). This article reviews the development of this system, including the use of novel optomechanics from Siskiyou Corporation to simplify system assembly, improve stability and reduce cost.

Convergent Dental had three main design goals for their system. First, providing a solution that provided a anesthesia and blood free procedure would be very attractive to dentists and patients alike. Second, they wanted to deliver a system that operated just like a traditional drill to simplify the transition and lower the barrier to dentists considering making such a fundamental switch. Finally, they determined that the ability to perform other (e.g., soft tissue) procedures better than existing technology (e.g., cauterizing) would enhance the utility and hence value, further supporting market adoption.

In terms of the laser, while both carbon dioxide (CO_2) lasers operating at 10.6 µm and erbium lasers with output at 2.9 µm have been used for dental applications in the past, Convergent Dental's engineers didn't feel that either of these were optimal for Solea.

The convergent Dental laser system stores numerous scanning patterns that create cuts and holes like various traditional drill bits. These patterns are selected by the dentist from a point and click intuitive control software screen.

In both cases, the light is poorly absorbed by dental enamel making it difficult for them to rapidly cut hard tissue (teeth). Instead, Solea uses a custom isotopic (oxygen-18) CO_2 laser from Coherent that emits at 9.3 µm, a wavelength chosen to match a strong absorption peak in hydroxyapatite, the major component in dental enamel. Consequently, the cutting efficiency is very high, minimizing the amount of heat generated in the tooth. In addition, the handpiece also applies cold water misting to the tooth as it is being machined.

No anesthesia 95% of cases

As a result of the low thermal loading and the laser pulsing characteristics, Solea dentists report more than 95% of their hard and soft tissue procedures can be completed without anesthesia. This saves time, and Convergent Dental claims this enables dentists to perform more additional procedures per day. The value of the system is further enhanced because the 9.3 µm CO_2 laser also excels at soft tissue cutting, and can even work on bone.

However, given the history of lasers in dentistry, the developers believed they needed to offer more than just a high return on investment (ROI). They also felt dentists would be more likely to purchase and use the system if it mimicked the use of a traditional drill as closely as possible.

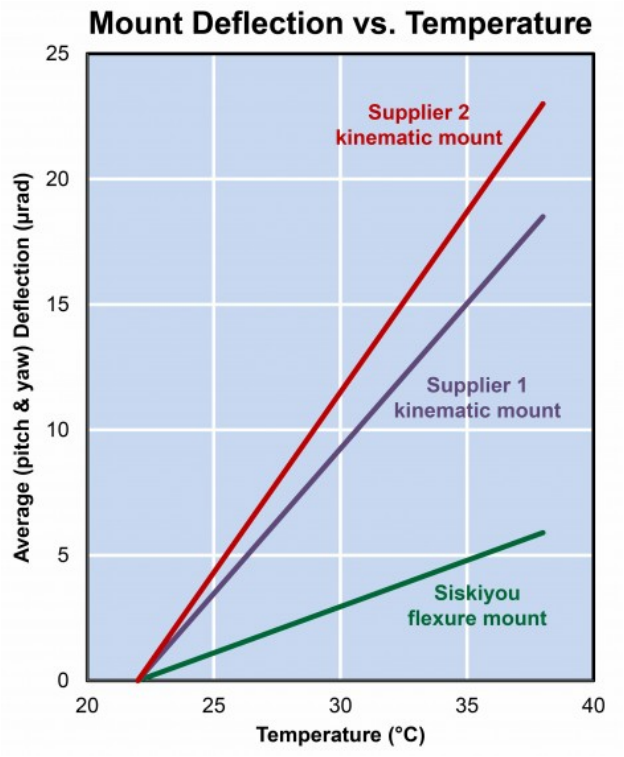
To deliver this functionality, designers included miniaturized galvanometer mirrors in the Solea handpiece. In operation, the dentist simply points and clicks at images of various drill bit diameters in the system software. The laser beam is then scanned to produce a cut pattern virtually identical to the one that a conventional drill bit would deliver. These patterns vary from 0.25 to 1.25 mm in diameter. Examples include a high speed, small drill bit for fast cutting, and a rough cutter that

creates a final hole surface ideal for filling with bonding material. The system even has a foot pedal on/off/speed controller, just like a traditional drill, which adjusts the laser pulsing rates to mimic changing the drill speed.

Obviously, optical alignment of the laser is critical in this sophisticated scanning system, in terms of precision, immunity to vibrational shifts, long-term stability and insensitivity to changes in ambient temperature. Moreover, Convergent Dental sources the laser and the articulated arm beam delivery assembly from two different vendors. The company has to mate and align these two sub-systems together without imposing unnecessarily tight manufacturing specifications on their opto-mechanical registration. The company solved these challenges by interfacing the two parts using novel adjustable, lockable, flexure beamsplitter mounts from Siskiyou.

Minimizing temperature-dependent drifts

Compared to other mounts, flexures offer the most favorable combination of performance, size and cost characteristics, making them the most common choice for OEM system builders. An important recent innovation in flexure mount technology is the development of next-generation products having monolithic construction.



Traditional two axis flexure mounts consist of three separate plates attached to two individual leaf springs using screws or spot welding. In contrast, these Siskyou monolithic mounts are machined entirely *from a single piece of metal*, including plates, springs and all. This construction confers an important advantage for systems that must maintain precise alignment. Specifically, the entire assembly expands or contracts uniformly with temperature changes. This is not true of a traditional flexure mount, where the different spring and plate materials can expand at different rates, resulting in changes in pointing. Plus, monolithic construction translates into improved heat transfer through

the entire mount. Together, this makes their locked alignment relatively insensitive to ambient temperature changes. Obviously minimizing temperature dependent drifts is important in a product that is used in a dentist's office, rather than a highly controlled environment like a semiconductor fabrication facility.

Leveraging advances

Convergent Dental leveraged advances in laser technology, software control and optomechanical mounts to create a system that delivers advanced functionality and improved patient comfort, while remaining reliable and cost effective enough for widespread market acceptance. Hopefully, we'll all reap the benefit of this at our next dental appointment.

Written by John Wingerd, Siskiyou Corporation, Grants Pass, Oregon (US)