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Short Communication

Automated Dental Preparation: Current Advances and Future Directions

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Introduction

The integration of advanced robotic systems in dentistry offers a substantial transformative potential [1]. By incorporating the extensive knowledge and technical expertise of dental technicians and experienced dentists into sophisticated software, these robotic systems can achieve precision and consistent manufacturing outcomes [2]. This article aims to expose the pivotal breakthrough of robotics in prosthodontics, promoting both technical innovation and theoretical advancements.

Evolution of robotic systems

In the context of modern scientific and technological advancements, robotics has emerged as a crucial area of research and societal interest. Robotic procedures in dentistry offer substantial advantages over traditional manual methods.

These advantages include enhanced precision achieved through 3D digital modeling, improved stability to eliminate hand tremors, and increased efficiency in operation times.

Furthermore, robotic systems can reduce patient anxiety and discomfort by delivering highly precise results through advanced sensors and actuation mechanisms.

The effective integration of robotics in prosthetic dentistry is expected to standardize dental preparation processes. While the preparation of teeth for crowns and bridges is considered as a standard procedure, it could present significant challenges, including the need to reduce tooth size while preserving maximum enamel tissue [3].

Yuan., *et al*. overcame the limitations of traditional manual techniques by employing a picosecond laser integrated with three-axis numerical control for automated tooth preparation. This approach demonstrated significant enhancements in safety, accuracy and efficiency, highlighting the potential of robotic technology to advance the precision and effectiveness of dental procedures [4].

In 2013, the LaserBot microrobot was introduced, enabling precise three-dimensional control of a femtosecond laser beam for clinical dental crown preparation. Researchers conducted

experiments using wax, resin, and teeth with a system integrating robotic and laser technologies for automated 3D dental preparation. The findings demonstrated that this robotic system successfully met the requirements for dental crown preparation in standard clinical settings [4,5]. Despite these advances, the time required for this robotic system was significantly longer than anticipated. To address this issue, the same research team developed an advanced automated robotic device employing ultrashort pulse lasers, controlled with high precision through 3D motion planning software [3,5].

This new system demonstrated both accuracy and feasibility in tooth preparation, reducing the average preparation time for newly extracted intact human first molars to 17 minutes.

Robotic vs. Freehand dental preparation

Otani., *et al*. conducted a comparative study to evaluate the accuracy and precision of an automated robotic dental preparation system for porcelain veneers compared to conventional freehand techniques. The results showed that while the robotic system achieved a level of accuracy similar to that of the traditional method, it demonstrated lower precision. This suggests that although the robotic system can meet the desired clinical outcomes in terms of overall placement, its ability to consistently replicate fine details and achieve tight tolerances might be less reliable than freehand techniques, which could impact the quality of the final restoration [2].

Automated dental preparation systems offer high precision and accuracy, consistent performance for repeated use, and the capability to process and evaluate quantitative data with great reliability. However, these systems lack situational judgment and cannot integrate qualitative information, requiring continuous oversight by an experienced dentist which could complicate their implementation [3,4].

The efficacy of these technologies is highly dependent on precise data entry, which requires the expertise of a qualified personnel to ensure optimal performance. Its accuracy can also be affected by variations in tooth structure and composition across different demographics.

Furthermore, the patient acceptance and compliance should be considered as critical variables. Research indicates that men generally exhibit a higher inclination for accepting robotic medical procedures compared to women.

Conclusion

The integration of robotic systems into dentistry markedly enhances precision and reproducibility. Nonetheless, progress in robotic dentistry is impeded by the limited availability of accessible systems and a shortage of specialized expertise required for the effectiveness of programming and regulation of these technologies.

Consequently, progress in this domain is heavily reliant on effective interdisciplinary collaboration between dental professionals and engineers.

This collaboration is expected to progress as advancements in robotics introduce new communication methods and programming models, promoting wider adoption and improved efficiency of robotic systems in dental practices.

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