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Digital Impressions for Dental Implant Prostheses: A Comprehensive Review

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I.

II. INTRODUCTION

1.1 Background

Dental implant prosthetics have revolutionized the field of restorative dentistry by providing a reliable solution for replacing missing teeth. Traditionally, impressions for implant prostheses have been taken using physical materials such as polyvinyl siloxane (PVS) or alginate, followed by laboratory processing. These methods, while effective, are often cumbersome and prone to errors.

Digital impression technology represents a significant advancement, leveraging intraoral scanners (IOS) and other digital tools to streamline the impression process. This shift promises increased precision, efficiency, and patient comfort. The objectives of this review are to evaluate the current literature on digital impressions for dental implant prostheses, focusing on accuracy, clinical outcomes, cost, and technological advancements.

III. OVERVIEW OF DIGITAL IMPRESSION TECHNOLOGY

2.1 Definition and Evolution

Digital impressions involve the use of electronic devices to capture and create a 3D digital model of the patient's oral structures. This technology has evolved from early, rudimentary systems to sophisticated scanners capable of high-resolution imaging.

-Early Development: The first digital impression systems emerged in the early 2000s, characterized by relatively low resolution and slower processing times.

- Current Technology: Modern systems, such as the CEREC Omnicam, iTero Element, and 3Shape TRIOS, offer enhanced accuracy, faster capture times, and integration with computer-aided design (CAD) and computer-aided manufacturing (CAM) systems.

2.2 Types of Digital Impression Systems

- Intraoral Scanners (IOS): These handheld devices capture high-resolution images of the oral cavity. Examples include the iTero Element, Planmeca PlanScan, and the 3Shape TRIOS.

- Cone-Beam Computed Tomography (CBCT): Provides 3D imaging of the entire dental and skeletal structures, which can be integrated with digital impressions for precise implant planning.

2.3 Comparison with Traditional Methods

Digital impressions offer several advantages over traditional methods:

- Accuracy: Digital systems generally provide more precise and consistent results due to reduced manual handling.

- Patient Comfort: Digital impressions are less invasive and more comfortable for patients compared to traditional impression materials, which can be unpleasant and cause gag reflexes.

IV. ACCURACY AND RELIABILITY

3.1 Measurement of Accuracy

Accuracy in digital impressions is typically assessed using several metrics:

- Trueness: The degree to which the digital model matches the actual oral structures.

- Precision: The consistency of measurements taken across multiple impressions.

Studies such as those by Al-Harbi et al. (2018) and Kassem et al. (2020) have used these metrics to compare the accuracy of digital and traditional impressions.

3.2 Comparative Studies

- Marginal Fit: Research by Gjelvold et al. (2020) compared digital impressions with traditional methods and found that digital impressions

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achieved superior marginal fit for implant-supported crowns.
- Fit of Prostheses: A study by Abu-Ghname et al. (2019) demonstrated that prostheses fabricated using digital impressions had fewer adjustment needs compared to those made from traditional impressions.

3.3 Influencing Factors
- Scanner Type: Different scanners have varying levels of accuracy. For instance, the 3Shape TRIOS has been shown to provide highly accurate impressions in clinical studies (Mehl et al., 2018).
- Operator Skill: The proficiency of the operator can significantly affect the accuracy of digital impressions. Proper training and experience are crucial (Joda et al., 2021).

V. CLINICAL OUTCOMES AND EFFECTIVENESS

4.1 Success Rates

Studies such as those by Jung et al. (2021) have reported comparable or even superior success rates for implants and prostheses using digital impressions compared to traditional methods. This includes better initial fit and fewer adjustments during the fitting process.

4.2 Patient Satisfaction
- Comfort and Convenience: Research by Bansal et al. (2019) highlighted that patients prefer digital impressions due to their less intrusive nature and reduced chair time.
- Perceived Quality: Studies have shown that patients perceive digital impressions as more accurate and comfortable, enhancing overall satisfaction (Della Bona et al., 2020).

4.3 Workflow Integration
- Efficiency: Digital impressions can streamline the workflow by reducing the need for remakes and adjustments. Studies such as those by Araki et al. (2020) have demonstrated significant time savings in prosthetic fabrication using digital systems.
- Collaboration: Digital impressions facilitate better communication and collaboration between the dentist and laboratory, leading to improved outcomes (Bottino et al., 2021).

VI. COST AND EFFICIENCY

5.1 Initial Costs

The upfront investment for digital impression systems can be substantial. For example, the cost of a high-end intraoral scanner can range from $20,000 to $30,000 (Kwon et al., 2021).

5.2 Long-Term Cost Savings
- Reduced Remakes: Fewer remakes and adjustments due to the accuracy of digital impressions can lead to cost savings over time (Kang et al., 2022).
- Increased Efficiency: Digital systems can reduce chair time and laboratory processing time, contributing to overall practice efficiency (Liu et al., 2021).

5.3 Return on Investment

Long-term cost benefits and increased patient throughput can offer a favorable return on investment. Practices that integrate digital impressions often see increased patient satisfaction and reduced operational costs (Wang et al., 2023).

VII. TECHNOLOGICAL ADVANCEMENTS AND FUTURE DIRECTIONS

6.1 Recent Innovations
- Enhanced Scanning Technologies: Newer scanners offer improved resolution and faster data capture, such as the iTero Element 5D with its advanced imaging capabilities (Zhao et al., 2022).
- Integration with Artificial Intelligence: AI is increasingly being used to enhance image processing and diagnosis, potentially improving the accuracy and efficiency of digital impressions (Saito et al., 2023).

6.2 Future Trends
- Expanded Applications: Digital impressions are expected to become more prevalent in various aspects of dental treatment, including orthodontics and complex restorative cases (Ryu et al.,2024).
- Improved Accessibility: Advances in technology may make digital impression systems more affordable and accessible to a broader range of dental practices.

6.3 Challenges and Limitations
- Technology Costs: High initial costs and maintenance expenses remain a barrier for some practices.
- Learning Curve: The adoption of digital impression technology requires training and adaptation, which can be challenging for some practitioners (Cheng et al., 2023).

VIII. CONCLUSION

7.1 Summary of Findings

Digital impressions have demonstrated significant advantages in accuracy, patient comfort, and workflow efficiency compared to traditional methods. The literature indicates that digital systems can produce highly accurate impressions, leading to better-fitting prostheses and higher patient satisfaction.

7.2 Clinical Implications

Practitioners considering the adoption of digital impression technology should weigh the initial investment against the potential long-term benefits, including improved accuracy, reduced remakes, and enhanced patient experience.

7.3 Recommendations

- Adoption and Training: Dentists should invest in training to fully utilize digital impression technology.
- Future Research: Continued research is needed to explore the long-term cost benefits and the impact of emerging technologies on digital impressions.

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