Applicability of CAD/CAM systems in implant prosthesis

Aplicabilidade de sistemas CAD/CAM na prótese sobre implante

Aplicabilidad de los sistemas CAD/CAM en prótesis sobre implantes

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ABSTRACT
CAD/CAM technology has been applied in Dentistry, especially in the areas of dental prosthesis and implant dentistry. This study analyzed the advance of CAD/CAM technology in the area of Implant Prosthesis, highlighting its advantages, characteristics and clinical applicability. A review of the literature was made from scientific articles published in the last ten years. The bibliographic search was done through the Medline database (PubMed). It was verified that the CAD/CAM assisted technology is made for the manufacture of implants on mediate and immediate loading implant. As well as in guided implant placement surgeries. This technique promotes greater predictability in treatment, high rates of implant and prosthesis survival, as well as patient satisfaction.

KEYWORDS: Computer-aided design. Prostheses and implants. Dental implants.

RESUMO

A tecnologia CAD/CAM tem sido aplicada em odontologia, especialmente nas áreas de prótese dentária e implantodontia. Este estudo analisou o avanço da tecnlogia CAD/CAM na área de prótese sobre implante, destacando suas vantagens, características e aplicabilidade clínica. Foi realizada uma revisão da literatura a partir de artigos científicos publicados nos últimos dez anos. A busca bibliográfica foi realizada na base de dados Medline (PubMed). Verificou-se que a tecnologia assistida por CAD/CAM é realizada para fabricação de próteses sobre implantes de carga mediata e imediata. Bem como em cirurgias guiadas para colocação de implantes. Essa técnica promove maior previsibilidade no tratamento, altas taxas de sobrevivência de implantes e próteses, além de satisfação do paciente.

PALAVRAS-CHAVE: Desenho assistido por computador. Próteses e implantes. Implantes dentários.

RESUMEN

La tecnología CAD/CAM se ha aplicado en odontología, especialmente en las áreas de prótesis e implantología dental. Este estudio analizó el avance de la tecnología CAD/CAM en el campo de las prótesis sobre implantes, destacando sus ventajas, características y aplicabilidad clínica. Se realizó una revisión de la literatura a partir de artículos científicos publicados en los últimos diez años. La búsqueda bibiográfica se realizó en la base de datos Medline (PubMed). Se encontró que la tecnología asistida por CAD/CAM se utiliza para la fabricación de prótesis sonbre implantes con carga inmediata e inmediata. Así como cirugías guiadas para la colocación de implantes. Esta técnica promueve una mayor previsibilidad en el tratamiento, altas tasas de supervivência para implantes y prótesis y la satisfacción del paciente.

PALABRAS CLAVE: Diseño assistido por computadora. Prótesis e implantes. Implantes dentales.

INTRODUCTION

The first computer assisted dental care system (CAD/CAM) came about through Cerec (Ceramic Restoration of Esthetic Ceramics) in the mid-1980s. This technology has been growing in popularity, there has been a considerable increase in the number of systems available only in recent years, as patients' aesthetic expectations are increasing and prosthetic path options are currently evolving[1-2].

One of the main reasons for this is that intraoral scanners have become better, smaller and faster, while design software has become easier to use. Many work steps are now automated and a wide variety of materials is available for dental office applications[1].

These advances have driven the rapid increase in the range of indications for dentistry, especially in the areas of dental prosthesis, implantology and orthodontics, and have paved the way for new strategies and treatment planning. Digital printing techniques based on intraoral scanners are already superior to conventional printing techniques in certain respects[1].

The quality of the adjustment of digitally designed dental restorations is constantly improving due to advances in milling technology. Because of the large number of new possibilities, it is only a matter of time before office systems become a standard component of dental practice[1].

The irreversible trend towards digitization and technology in dentistry has resulted in technical progress and continuous changes in conventional work. In particular, Implantology and Dental Prosthodontics have benefited from a multitude of interesting new possibilities. Three-dimensional (3D) computerized radiography and digital surface scanning can be invaluable in terms of retrograde planning and make implant surgery and denture manufacturing more predictable. Through digital intraoperative scanning of the implant position, the concept of a digital one-time pillar allows the insertion of individual crowns made with CAD/CAM aid instantly after implant placement[3].

This technology allows the angular correction of the emergence of the screw in the prosthesis[4]. Although computer aided design and the manufacture of CAD/CAM assisted manufacturing of removable dental prostheses (CRDPs) have gained popularity, conventional prints are still common for prosthetic treatment. These need to be scanned and converted into edentulous virtual models with a laboratory print verification protocol during the fabrication of the prosthesis[5].

The present study analyzed through a literature review the advancement of CAD/CAM technology in the area of implant prosthesis, highlighting its advantages, characteristics and clinical applicability.

MATERIAL AND METHODS

A review of the literature based on the research of scientific articles obtained from the International Health Sciences Literature database - Medline (PubMed), with the following keywords: "CAD/CAM" AND/OR implantology; CAD/CAM; computer aided design/computer aided manufacturing; implantodontia.

We included studies that reported the characteristics of CAD/CAM systems in implant prosthesis. The research period consisted of the last ten years. Scientific articles that did not fit the proposed theme and the inclusion criteria were excluded. The search process was carried out in three phases: search for titles, analysis of abstracts and identification of full text articles.

RESULTS

CAD/CAM Technology in Implant Prosthesis

The retrospective study evaluated 581 implants installed in 194 patients. The patients were followed for an average period of 60.6 months. In eighty-three patients, the implants were equipped with CAD/CAM or cast bar. At the last follow-up, 10 implants failed in eight patients. The implant prosthesis showed high implant and prosthesis survival rates, low complications, high patient satisfaction and good biological parameters in long-term follow-up[6].

Evaluated the mechanical and thermal fatigue strength of thirty crowns manufactured by CAD/CAM, being: feldspathic, lithium disilicate and monolithic modified by resins. They were cemented into a universal post-abutment pillar at a constant load of 50 N. The resin-modified group was the least resistant, followed by the feldspar and lithium disilicate groups. It was possible to conclude that all materials tested by CAD/CAM technology can be used as monolithic mo-

lar crowns, supported by implants[3].

In a study evaluated the influence of the manufacturing method and the design on the marginal and internal adjustment of total temporary restorations. Four groups were defined: edge, chamfer, rounded shoulder, rounded bevelled shoulder. All preparations were digitized. The 3D-printed restorations showed a significant difference in comparison to the milled restorations at all points. Printed interim restorations exhibit less internal and marginal difference than machined restorations. However, for both techniques, all values were within reported values for CAD/CAM restorations[7].

In a prospective clinical study evaluated the clinical performance of monolithic lithium disilicated crowns generated by CAD/CAM after six years. Forty-one posterior total crowns made of lithium disilicate ceramics were inserted in 34 patients through this technology and the authors concluded that the clinical performance of the monolithic disilicated lithium crowns in the posterior region was completely satisfactory[8].

Lithium disilicate can be easily machined by CAM techniques in its metasilicate state. Due to the properties of slightly lower materials, the material is still not recommended for fixed three-unit dental prosthesis (PDF), as is the case for the press material up to the second premolar. Therefore, conducted a clinical study to evaluate the performance of CAD/CAM manufactured lithium disilicate PDFs. A total of 32 previous and subsequent PDFs were provided for 32 patients. Twelve PDFs were manufactured by CAD/CAM. The first maintenance occurred 6 months after insertion and then annually. PDFs were classified according to biological and technical complications. After an average observation time of 46 months, three endodontic complications occurred in two PDFs and one fracture, one prosthesis was removed. Thus, the free-of-failure rate and the complication-free rate were revealed as 93 and 83%, respectively. Obtaining promising results despite the limited observation period[9].

Guided Surgeries in Implantodontics for CAD/CAM Technology

Guided implant surgery is performed with drill guides that are produced in the virtual tooth model using CAD/CAM technology. The prerequisite for this workflow is the alignment of patients in concomitant computed tomography (CBCT) and scanning surface (registration). Dental restorations can cause deteriorating image artifacts in the CBCT data, which, in turn, can impact the registration process. User influence and preprocessing of data and image artifacts on record accuracy were examined in the study[10]. The authors used CBCT data and intraoral surface scans of 36 patients for the planning of virtual implants in coDiagnostiX (Dentalwings, Montreal, Canada). They concluded that the deviation between CBCT and surface scanning model resulting from inaccurate recording is transferred to the surgical field and results in a deviation between the planned and actual position of the implant.

The accuracy of registration in commercial virtual implant planning software is significantly influenced by the pre-processing of imported data by the user and by the number of restorations, resulting in clinically uncorrected deviations coded in drill guides[10].

Currently, different computer supported systems are available to optimize and facilitate implant surgery. Guided implant surgery clearly reduces imprecision compared to free surgery, defined as the deviation between the planned and the final position of the implant in the mouth. It may be recommended for the following clinical indications: complex anatomy, need for minimally invasive surgery, optimization of implant placement (eg aesthetic cases) and immediate loading. The transfer of implant planning data uses a software program appropriate to the operational field and remains the most difficult part. Digital technology evolves rapidly and new developments will allow for further improvements in reducing inaccuracy[10].

Evaluated the clinical results of implants placed using different types of surgical guides assisted by CAD/CAM technology, including partially guided and totally guided models, and determined the accuracy of these guides. In total, 111 implants were placed in 24 patients using CAD/CAM surgical guides. After insertion of the implant, the positions and angulations of the implants placed in relation to those planned were determined using special software that combined pre- and postoperative computed tomography (CT) images, and the deviations were calculated and compared between the different guides and models. Tooth-supported surgical guides can be more accurate than mucosa-supported guides, while partially and fully guided templates can simplify surgery and assist in optimal placement of the implant[11].

DISCUSSION

Digital technologies are of increasing importance in clinical dentistry, including Implantology. Computers can help improve patient care in various ways and at different times during therapy. New technologies allow you to obtain patient data in ways other than traditional prints. These predominantly cover the intra and extraoral surface scanning, and radiographic capture of rigid craniofacial structures. The implementation of the planned treatment becomes more precise and predictable. In addition, computer technologies help improve the quality of reconstructions. In particular, computers improve control over the design of interim and final reconstructions and provide the ability to fabricate reconstructions using industrially controlled manufacturing processes. These processes are ideally performed under higher standards of quality and predictability than traditional ones. New technologies can help to evaluate treatment outcomes more accurately and economically and provide new insights into the optimal therapeutic choice[10].

Advances in the field of Implantology, such as three-dimensional imaging, implant planning software, CAD/CAM technology and computer-guided implant surgery have led to the computerization of Implantology. This three-dimensional computer-generated implant and surgery planning not only allowed a precise preoperative evaluation of anatomical limitations, but also facilitated the preoperative planning of implant positions along with the placement of virtual implants and the transfer of treatment plans to the surgical phase via static or dynamic guided (navigated) systems aided by CAD/CAM. The dental treatment performed through this technology is highly predictable and of a minimally invasive nature[12].

The advantages of CAD/CAM technology are: it facilitates minimally invasive surgical procedures with surgical guides, and greatly improves the predictability of implant surgery. Allows immediate loading, with the pre-surgical construction of molded restorations and precise, customized adjustments[13-14].

Guided implant surgery involves the virtual placement of implants and the production of drill guides using CAD/CAM procedures. With virtual implant planning systems, the surgical guide can be virtually designed on the tooth surface model and produced internally using a 3D printing device[15].

For dental planning of dental implants, anatomical data of the patient are required. Computed tomography (CT) or computerized tomography (CT) are used to display a three-dimensional image of the mandible to identify anatomical structures such as the inferior alveolar nerve, maxillary sinus, and roots of neighboring teeth[16].

Technological advances allowed the development of this technique in dental treatments mainly in the areas of dental prosthesis and implant dentistry. CAD/CAM technology provides predictability in the treatment both for the manufacture of prostheses (even in immediate loads) and for guided surgeries for implant placement.

CONCLUSION

CAD/CAM technology has clinical applicability in guided surgeries for implant placement, and in the manufacture of implants on implants with immediate and medium loads. This technique promotes greater predictability in treatment, high rates of implant and prosthesis survival, as well as patient satisfaction. Digital technology evolves rapidly and new developments will allow for further improvements in reducing inaccuracy.

REFERENCES

1. Zaruba M, Mehl A. Chairside systems: a current review. Int J Comput Dent. 2017;20(2):123-49.

2. Wittneben JG, Gavric J, Belser UC, Bornstein MM, Joda T, Chappuis V, et al. Esthetic and clinical performance of implant-supported all-ceramic crowns made with prefabricated or cad/cam zirconia abutments: a randomized, multicenter clinical trial. J Dent Res. 2017;96(2):163-70.

3. Schubert O, Beuer F, Guth JF, Nold E, Edelhoff D, Metz I. Two digital strategies in modern implantology - root--analogue implants and the digital one-abutment/one--time concept. Int J Comput Dent. 2018;21(2):115-31.

4. Anitua E, Flores C, Pinas L, Alkhraisat MH. Frequency of technical complications in fixed implant prosthesis: the effect of prosthesis screw emergence correction by computer-aided design/computer--aided manufacturing. J Oral Implantol. 2018;44(6):427-31.

5. Peng L, Chen L, Harris BT, Bhandari B, Morton D, Lin WS. Accuracy and reproducibility of virtual edentulous casts created by laboratory impression scan protocols. J Prosthet Dent. 2018;120(3):389-95.

6. Tallarico M, Ortensi L, Martinolli M, Casucci A, Ferrari E, Malaguti G, et al. Multicenter retrospective analysis of implant overdentures delivered with different design and attachment systems: results between one and 17 years of follow-up. Dent J. 2018;6(4):71.

7. Alharbi N, Alharbi S, Cuijpers V, Osman RB, Wismeijer D. Three-dimensional evaluation of marginal and internal fit of 3D-printed interim restorations fabricated on different finish line designs. J Prosthodont Res. 2018;62(2):218-26.

8. Rauch A, Reich S, Schierz O. Chair-side generated posterior monolithic lithium disilicate crowns: clinical survival after 6 years. Clin Oral Investig. 2017;21(6):2083-9.

9. Reich S, Endres L, Weber C, Wiedhahn K, Neumann P, Schneider O, et al. Three-unit CAD/CAM-generated lithium disilicate FDPs after a mean observation time of 46 months. Clin Oral Investig. 2014;18(9):2171-8.

10. Flugge T, Derksen W, Te Poel J, Hassan B, Nelson K, Wismeijer D. Registration of cone beam computed tomography data and intraoral surface scans - A prerequisite for guided implant surgery with CAD/CAM drilling guides. Clin Oral Implants Res. 2017;28(9):1113-8.

11. Geng W, Liu C, Su Y, Li J, Zhou Y. Accuracy of different types of computer-aided design/computer-aided manufacturing surgical guides for dental implant placement. Int J Clin Exp Med. 2015;8(6):8442-9.

12. Gulati M, Anand V, Salaria SK, Jain N, Gupta S. Computerized implant-dentistry: advances toward automation. J Indian Soc Periodontol. 2015;19(1):5-10.

13. Spector L. Computer-aided dental implant planning. Dent Clin North Am. 2008;52(4):761-75.

14. Fortin T, Bosson JL, Isidori M, Blanchet E. Effect of flapless surgery on pain experienced in implant placement using an image-guided system. Int J Oral Maxillofac Implants. 2006;21(2):298-304.

15. Flugge TV, Nelson K, Schmelzeisen R, Metzger MC. Three-dimensional plotting and printing of an implant drilling guide: simplifying guided implant surgery. J Oral Maxillofac Surg. 2013;71(8):1340-6.

16. Bornstein MM, Scarfe WC, Vaughn VM, Jacobs R. Cone beam computed tomography in implant dentistry: a systematic review focusing on guidelines, indications, and radiation dose risks. Int J Oral Maxillofac Implants. 2014;29 (Suppl):55-77.