International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 8; Issue 01(A); January 2019; Page No. 16750-16754
DOI: http://dx.doi.org/10.24327/ijcar.2018.16754.3108

Research Article

DIGITAL WORKFLOW IN IMPLANT DENTISTRY: A COMPREHENSIVE REVIEW

Suresh Kamble., Ajit Jankar., Sandeep Fere., Dishita Chokhani., Susheen Gajare and Shashi Patil

Department of Prosthodontics, Maharashtra Institute of Dental Science and Research, Latur, Maharashtra

A R T I C L E I N F O

Article History:
Received 4th October, 2018
Received in revised form 25th October, 2018
Accepted 18th December, 2018
Published online 28th January, 2019

Key words:
Intra-oral scanning, dental implants, implant planning software, CADCAM manufacturing

A B S T R A C T

In the era of digitalization, implant dentistry heralds the wave of digital revolution. Due to the evolution of newer equipments and techniques the diagnosis and treatment of the cases are becoming simpler and more precise. With the ongoing ingress of new hardware and software into the market, dental technology has the capability to invade every area of clinical implant dentistry. Its application generally begins from the pre-operative stage for the diagnostic scanning with the help of intra-oral scanner and cone beam computed tomography.

These modalities, along with implant planning software, enables for the planning as well as the guided surgical placement of dental implants. Technology can further be applied to the prosthetic phase of implant by fabricating the interim and final restorations of the implants, determining its use in every stage of implant dentistry. It also helps the dentist to discuss and exhibit the final outcome of the treatment with the patient through the digital data obtained. This leads to create a positive impact on patient providing greater patient acceptance. The propose of the article is to illustrate the application of digital technology in the pre-operative planning phases, surgical placement and prosthetic stages of implant treatment

INTRODUCTION

Digital dentistry comprises of wide range of technologies that accompanies the communication, documentation, manufacture and delivery of dental therapy within the sphere of computer-based algorithms. Extensive distribution of digital technologies in dentistry initiated in the early 1990's with the introduction of digital radiography and the earliest versions of intraoral scanning and computer-assisted design and computer-assisted manufacturing (CAD/CAM) crowns. The evolution of cone beam computed tomography (CBCT) brought a new blow of exhilaration as three-dimensional images of the craniofacial region offered recent edge in diagnosis and therapy. When continuous enhancement in hardware, software, and materials amalgamated in the early 2000, new achievements in clinical dentistry were recognized.

Implant dentistry is one clinical area where digital technology can be utilized to its fullest extent. Guided implant surgeries bestowed enhanced therapeutic workflow and safety. With increasing availability, reduced radiation and lower costs of three-dimensional imaging because of cone beam computer tomography, pre-operative three-dimensional implant planning is becoming more popular in dentistry and cranio-maxillofacial surgery.

Corresponding author:* **Suresh Kamble
Department of Prosthodontics, Maharashtra Institute of Dental Science and Research, Latur, Maharashtra

Navigated implant surgery provides for improved implant positioning at anatomically sensitive structures such as the maxillary sinus, the mandibular canal, and the mental foramen. Recently a radiological template-free implant guided surgery workflow has been introduced for partially edentate patients. As soon as the techniques and advantages flourished, current decade of activity by early adopters fueled innovation. Digital technology is driving remarkable change in the practice of dental implantology[1].

The Benefits of Digital Technology

1. The improved communication between dentists, patients, dental laboratory technicians. Coherence in communication is enhanced by electronic patient records that presents platform for direct exchange of views. Along with this it also helps the dentist to discuss and present the final outcome of the treatment to the patient, achieving greater patient acceptance.
2. Digital impression techniques provide precise recording of the details than conventional techniques, due to which we obtain better marginal and internal fit of fixed restorations. The improved quality of care acquired through digital technology is a major clinical advantage of digital technologies in dentistry. The quality of prostheses fabricated by digital technology is similar or enhanced compared to conventional techniques.

3. It helps to document the individual patient data. Keeping of virtual diagnostic casts is feasible due to the high accuracy of the scanned image which leads to:
   a. Fabricating durable images without loss or damage of original casts.
   b. Collocation with other images for evaluation by innovative analytic and design software
   c. Human errors are eliminated
   d. The cost of storage is decreased.
   e. Due to precise storage of the data medico legal problems can be solved.
4. The last and critically significant benefit of digital technology in Prosthodontics is its positive impact on the patient experience.

Barriers to the Adoption of Digital Technology

A comprehensive review highlighted several recognizable barriers including:

a. Acceptance of change in the ongoing conventional process.
b. Learning advance techniques for digitalization
c. Absence of basic computer skills
d. Inter-professional and inter-system communications
e. Lack of Technical and expert support.

Lastly, while these opportunities and risks can be measured, it was recently suggested that the main barriers to dentists' adoption of new technology is its awareness.

Steps in implant-prosthetic digital workflow

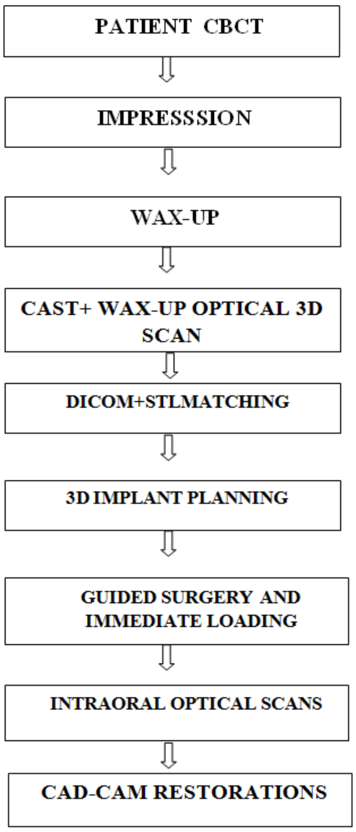

Fig 1 Implant-prosthetic digital workflow

Technology Associated with Surgical Placement of Implants

Diagnostic Intra-oral Scanning

Pre-surgical intra-oral scanning is the initial step where technology can be applied in implant dentistry (fig 2).

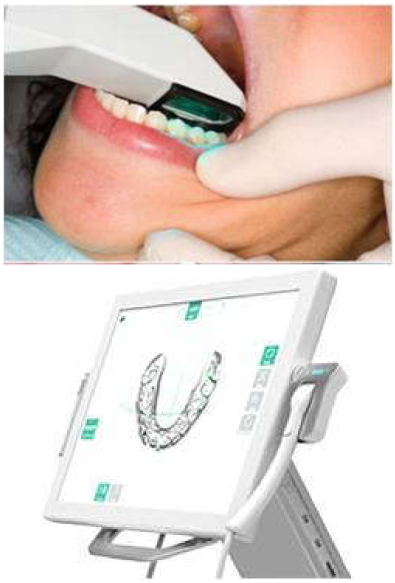

Fig 2 Digital impression for intraoral scanning

Due to their high accuracy, reliability, and reproducibility it designs, the digital models that have been shown to be as authentic as plaster cast models[2]. These attributes are related to the accuracy of the scanner and the mathematical algorithms used to design the digital model[3]. These scanners have gained continued penetrance into the market and increased patient preference due to its ability to procure and render three-dimensional models very swiftly and effortlessly[4].

Diagnostic Wax-up

After the diagnostic IO scans are attained, the next critical component to implant treatment planning and execution is the diagnostic wax-up. This allows for the creation of a three dimensional communication tool that guides the prosthetically driven implant planning and placement to be achieved. Using dental laboratory software, these wax-ups can be virtually planned (Fig. 3).

Fig 3 The pre-treatment intraoral scan is imported into the laboratory design software for digital diagnostic tooth setup

This allows the clinician and patient to visualize the case prior to treatment and make any adjustments to tooth shape, size, or morphology by using the tools within the software. Once the final design is accomplished, the wax-up can be produced via digital manufacturing.

CBCT Technology

The technological foundation for the surgical placement of dental implants is rooted in the information gained from a CBCT scan. This modality has grown in popularity and prevalence owing to its ability to capture three-dimensional structures with relatively short scan times and low dosages when compared to medical grade computed tomography[5]. The accuracy of the data acquired by these scans has been verified in the literature as has been its ability to assess and qualify the bone for future implant sites[6]. To this end, Timock revealed the CBCT's ability to discriminate alveolar bone thickness to be between "0.13 and 0.3 mm" and also demonstrated that CBCT measurements neither underestimated nor overestimated the bone thickness when compared to direct measurements[7]. These characteristics combine to make CBCT an invaluable tool when evaluating patients for implant placement.

Implant Planning Software

The most powerful way to use CBCT technology is in concern with implant planning software. These programs allow the user to view all of the characteristics of a future implant site by allowing for the precise assessment of bone volume, bone density, and restorative space availability in conjunction with the ability to identify and mark anatomic landmarks such as nerves, sinuses, and proximal teeth. Beyond site assessment, the most useful tool is the ability to virtually place an implant into the proposed site. This allows for accurate implant width, depth, and size determinations prior to surgery to aid in the pre-surgical planning stages. In addition to planning the implants relative to the bony sites they will occupy, most current implant planning platforms allow for truly prosthetically driven implant planning. This is accomplished via the import of information regarding the pre-surgical condition of the patient (via digitized stone casts or an intra-oral scan) and the proposed restorative plan (by means of a diagnostic wax-up) and merging those files with the CBCT scan of the patient. This allows for the visualization and planning of the implants to be idealized to support the proposed final prosthetic outcome (Fig. 4).

Fig 4 Implant planning software allows for merging of the pre-operative condition, proposed finalized tooth position, and the CBCT scan of the patient allowing for idealized implant and restorative planning.

This process can also be accomplished in the completely edentulous patient but from a slightly different workflow. With the edentulous patient, fiduciary markers are placed on their well-fitting complete denture and the patient has a CBCT taken while wearing their prosthesis. The denture is then removed from the patient's mouth and placed on the stand of the CBCT unit, and another CBCT scan is taken of the denture itself. This process is referred to as a "dual-scan" protocol. The implant planning software then merges both of these CBCT scans to allow for visualization of the denture on the edentulous ridge, thus allowing for proper implant planning relative to the tooth positions on the denture.

Computer-Guided Surgical Templates

The surgical plans generated by the implant planning software are then brought to full clinical realization by the fabrication of their corresponding computer-guided surgical templates. These surgical guides are made from either an additive steriolithographic (SLA) process or by a subtractive milling process. The actual manufacturing is dependent on the constraints of the planning software.

Fig 5 computer guided surgical template

Some software packages are associated with centralized printing centers and only allow for production through their approved channels. Conversely, other planning software generate files that allow the guides to be printed or milled by the manufacturing process of the users' choice ranging from a large milling center to their local lab and even to their own office. The benefits of using these types of surgical templates for the dental provider are immense. It has been shown that using a computer-generated surgical template allows for the optimization of implant location, angulations and depth[8]. This leads to a significantly lower chance of having a positional error at the time of implant placement when compared to free-handed surgery. Arisan's group demonstrated this showing an 88% probability of having a positional error with a free-handed approach to only a 6% probability using a computer-guided template. These benefits combine to allow for greater precision in implant placement with increased restorative simplicity[9,10]. The benefits of guided surgery are not only limited to those affecting the dental provider. Patients benefit vastly by experiencing significantly less intra-operative pain as well as post operative complications[11]. This increase in patient comfort has been linked to the benefit of not having to raise a flap for the surgery and has been shown to be the preferable way to execute guided surgery[12,13].

Technology Associated with the Restorative Phases of Implant Dentistry

The Clinical Use of Scan Bodies

Intra-oral scanning is also being applied in the restorative phase of implant dentistry. Intra-oral scan bodies have been developed for most major implant brands which allow for the use of the majority of intra-oral scanning devices on the market. These function as digital impression copings which allow for the implant brand, position, and timing to be registered and transferred to a digital model. All the needed information relative to provisional treatment, opposing arch, and bite registrations can be captured with intra-oral scanning devices. This workflow has been shown efficient and accurate for both dentate and edentulous cases[14]. From a patient and clinician perspective, this process offers a number of benefits. Most notably, it has been shown to be associated with quicker treatment times and enhanced patient experiences when compared to conventional impression techniques 15. In one paper, when given a choice for future restorations to be conventionally impressed or digitally impressed, all of the study participants prefer the digital workflow[16].

Abutment and Restoration Fabrication

The digital impressions from the clinician are then transferred through secure web portals to the dental laboratory. At this stage, the dental technician has the ability to continue using technology to design and manufacture all of the corresponding restorative components. These digital laboratory technologies tend to reduce material manipulation and the number of error introducing steps and thus have been associated with more efficient processes[17]. Custom abutments are designed digitally and milled out of the material of the clinician's choice. The abutment design file can then be imported back into laboratory design software and the final restorations can be planned and designed[18, 19]. Fabrication of the restorations is accomplished through milling, printing, or conventional processes (Fig. 6).

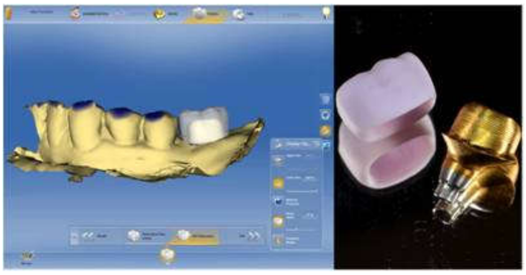

Fig 6 Final implant abutments and restorations are digitally designed and manufactured

These digital design and manufacturing methods have gained popularity due to their ability to simplify and streamline the complex process of restoration fabrication. When comparing this digital lab workflow to a conventional work flow, the digital work flow was shown to be three times efficient for the formation of fixed implant-supported crowns. This workflow also benefitted the clinician as the mean clinical adjustment and seating time where significantly lower than those restorations fabricated from a conventional workflow.

Summary

Digital technology brings supreme lead to dentistry. While this lead is often remarkable and clearly distinguish digital from conventional techniques. Further development in digital implant dentistry approximates the interfaces of surgical and prosthetic treatment steps: from the virtual planning, plotted on guidance template manufacturing, to the CAD/CAM-based design, including production of final prosthetic reconstruction.

CONCLUSION

In a day of constant innovation, digital technologies can be used to rationalize and make more systematic our dental implant treatment. The fully digital workflow not only permits the surgical and prosthetic decision making but also enable the communication within the dental team and with the patient. Further enhancement leading to a direct match between the intraoral scan and the CBCT are strongly recommended so as to design the so-called virtual patient.

References

1. Ludlow M, Renne W. Digital workflow in implant dentistry. Curr Oral Health Rep. April 2017:1-5.
2. Rossini G, Parrini S, Castroflorio T, Deregibus A, Debernardi C. Diagnostic accuracy and measurement sensitivity of digital models for orthodontic purposes: a systematic review. *Am J Orthod Dentofac Orthop*. 2016; 149:161-70.
3. Hack G, Patzelt S. Evaluation of the accuracy of six intra-oral scanning devices: an in-vitro investigation. JADA. 2015; 10:1-5.
4. Renne W, Ludlow M, Fryml J, Schurch Z, Mennito A, Kessler R, Lauer A. Evaluation of the accuracy of seven digital scanners: an in-vitro analysis based on 3-dimensional comparisions. J Pros Dent2016 JPD-D-16-00503R5.
5. Agbaje JO, Jacobes R, Maes F, Michiels K, Steenberghe D. Volumetric analysis of extraction socket using cone beam computed tomography: a pilot study on ex vivo jaw bone. *J Clin Periodontol*. 2007; 34:985-90.
6. Lund H, Grondahl K, Grondahl HG. Accuracy and precision of linear measurements in cone beam tomography Accuitomo tomograms obtained with different reconstruction techniques. Dentomaxillofacial Radiology. 2009; 38:379-86.
7. Timock AM, Cook V, McDonald T, Leo MC, Crowe J, Benninger BL, Covell D. Accuracy and reliability of buccal bone height and thickness measurements from cone-beam computed tomography imaging. Am J Orthod Dentofac Orthop. 2011; 140:734-44.
8. Di Giacomo G, Cury P, Araujo N, Sendyk W, Sendyk C. Clinical application of stereolithographic surgical guides for implant placement: preliminary results. *J Periodontol*. 2005; 76:503-7.
9. Arisan V, Karabuda C, Mumcu E, Ozdemir T. Implant positioning errors in freehand and computer-aided placement methods: a singleblind clinical comparative study. *Int J Oral Max Implants*.2013; 28:190-204.
10. Van Assche N, Vercruyssen M, Coucke W, Teugheis W, Jacobs R, Quirynen M. Accuracy of computer-aided implant placement. Clin Oral Imp Res. 2012; 23 (Suppl 6):112-23.
11. Nkenke E, Eitner S, Radespiel-Tröger M, Vairaktaris E, Neukam FW, Fenner M. Patient-centered outcomes comparing transmucosal implant placement with an open approach in the maxilla: a prospective, non-randomized pilot study. Clin Oral Implants Res. 2007; 18:809-14.
12. Fortin T, Bosson J, IsidoriM, Blanchet E. Effecct of flapless surgery on pain experienced in implant placement using an image-guided system. Int J Oral Maxillofac Implants. 2006; 21:298-304.
13. Arisan V, Bolukbasi N, Oksuz L. Implant surgery using boneand mucosa-supported steriolighographic guides in totally edentulous jaws; surgical and post-operative outcomes of computer-aided vs. standard techniques. Clin Oral Implants Res. 2010; 21:980-8.
14. Gherlone E, Cappare P, Vinci R, Ferrini F, Gastaldi G, Crespi R. Conventional versus digital impresions for "all-on-four" restorations. *Int J Oral Maxillofac Implants*. 2016; 31:324-30.
15. Joda T, Lenherr P, Dedem P, Kovaltschuk I, Bragger U, Zitzmann N. Time efficiency, difficulty, and operator's preference comparing digital and conventional implant

impressions: a randomized controlled trial. Clin Oral Impl Res.2016:1-6
16. Joda T, Bragger U. Patient-centered outcomes comparing digital and conventional implant impression procedures: a randomized crossover trial. Clin Oral Impl Res. 2015:1-5.
17. Abduo J, Bennamoun M, Tennant M, McGeachie J. Impact of digital prosthodontics planning on dental esthetics: biometric analysis of esthetic parameters. *J Prosthet Dent*. 2016; 115:57-64.
18. Joda T, Braegger U. Complete digital workflow for the production of implant-supported single- unit monolithic crowns. *J of Clin or Implant Res*. 2014; 25:1304-6.
19. Joda T, Katsoulis J, Bragger U. Clinical fitting and adjustment time for implant-supported crowns comparing digital and conventional workflows. Clin Impl Dent Relat Res. 2015:1-9.

How to cite this article:

Suresh Kamble *et al* (2019) 'Digital Workflow in Implant Dentistry: A Comprehensive Review', *International Journal of Current Advanced Research,* 08 (01), pp. 16750-16754. DOI: http://dx.doi.org/10.24327/ijcar.2019.16754.3108

****