PRECISION AND PREDICTABILITY:
Streamlining the Implant and Ortho Workflow

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Implant Planning and Treatment: The Digital Workflow

ABSTRACT

Implant treatment is a reliable treatment that is increasingly in demand for the replacement of missing teeth. During implant treatment planning, anatomical structures must be accurately identified and treatment must be planned from the perspective of the desired restorative result. This is of particular importance in the anterior region, where esthetics is a primary consideration. The digital workflow has improved the predictability and execution of implant therapy. It has also made it possible to increase accuracy, efficiency, and patient comfort during treatment and to reliably achieve an esthetic result.

LEARNING OBJECTIVES

The overall goal of this course is to provide information on the digital workflow for implant therapy. After completing this course, participants will be able to:

1. Describe key factors in implant treatment planning;
2. Review the digital workflow and the use of digital setups in implant treatment planning;
3. Outline implant components that can be viewed virtually; and,
4. Describe CAD/CAM digital technology as part of the digital workflow and its use for printed and milled components used during implant therapy.

INTRODUCTION

Implant treatment is a reliable and predictable treatment for the replacement of missing teeth, and demand for implant therapy continues to increase. With precise planning and consideration of all treatment aspects, implant-retained restorations have a good prognosis, result in patient satisfaction, and do not involve adjacent teeth. Subjective oral health improvement following single implant treatment has also been found to improve, especially for patients whose implants were placed in the anterior esthetic zone.

Clinician and patient expectations dictate that treatment planning consider anatomical, functional, and esthetic aspects of implant therapy for the desired long-term outcomes. The maxillary and mandibular anatomy and adjacent to the proposed implant site must be known. These will dictate the possible length of implants, and whether ridge augmentation/bone grafting/sinus lift is required to provide adequate bone height and volume. Buccal

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Sonia S. Leziy, DDS, received her dental degree from McGill University and post-graduate degree in periodontics from the University of British Columbia, Canada, where she is currently a clinical professor and sessional lecturer. Dr. Leziy is a Fellow of the Royal College of Dentists of Canada, a Fellow of the International Congress of Oral Implantologists, and a member of the Canadian Academy of Periodontists and the American Academy of Periodontists. In addition, she co-mentors a highly successful section of the Seattle Study Club. A national and international lecturer, Dr. Leziy has published extensively on the subjects of implant esthetics and related surgical and restorative techniques. She maintains a private practice in North Vancouver.
and palatal/lingual resorption of the alveolar ridge and undercuts can also result in the need for ridge augmentation, where defects would otherwise result in perforation of the bony plate or poor positioning of an implant.

Implants placed at an angle to compensate for inadequate bone volume can also compromise clinical outcomes by causing abnormal loading of the restored implant. This can increase bone loss beyond that which is physiological, and can also result in mechanical failure of the implant or restorative components. In addition, the implant must be placed in a three-dimensional position that will allow for an esthetic emergence profile, peri-implant soft tissue development, and a natural-looking definitive restoration. Factors influencing patient satisfaction with esthetics include the color and shape of the crown, and the amount of papillary fill. Treatment planning must address implant position relative to the crestal bone and buccal-lingual and mesio-distal dimensions, tissue type and volume, development of the peri-implant tissue and achievement of papillary fill, and the type of abutment and emergence profile of the final restoration for an esthetic result. Digital treatment planning and the digital workflow have improved the predictability and execution of implant therapy, especially in the esthetic zone.

**Digital Treatment Planning and the Digital Workflow**

Traditionally, an initial patient assessment for implant therapy included radiographs. However, radiographs do not provide a three-dimensional (3D) view. Cone beam computed tomography (CBCT) and computerized axial tomography (CAT), in addition to STL digital scans/impressions, are now available and used to obtain 3D digital images, with significant improvements in planning and diagnostic capabilities. Based on the risk of lingual plate perforation in the posterior mandible, for instance, it was concluded that CBCT scanning is essential for planning immediate implant placement. The implant planning software creates virtual models to visualize a virtual implant in the arch using 3D images and cross-sectional views captured using the digital scans. The result is an overview of the ideal implant position (Figure 1). 3D images and implant planning software show bone defects where resorption has occurred, and show the clinician during the treatment planning where insufficient bone volume is present and where anatomical structures are in close proximity. In the example shown, the patient had presented with generalized recession in the region 5-12 and failing teeth #7 and 9, while periapical radiographs revealed an apical bone defect in the area of tooth #7 and prior apical surgery in teeth #7 and 9. The preoperative axial view sections identified a narrow/slender ridge and large nasopalatine duct. Teeth #7 and 9 also appeared to have little/no overlying facial bone. The unfavorable ridge anatomy and bone defects coupled with clinical tissue challenges necessitated multistaged gingival tissue and bone grafting procedures prior to implant placement (Figures 2, 3).

Due to the complexity of the case, bone grafting was first performed and the implant would be placed later. The digital workflow...
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workflow continued with treatment planning of implants in sites #7 and 9, as shown by the Implant Studio screen capture of the axial section. The implant at site #7 was shown planned approximately 1.5 mm from the adjacent root, but staying distal to the nasopalatine canal (Figure 4). The planning of the precise implant position also allowed for use of an angled screw channel for a definitive screw-retained restoration. A new CBCT scan and optical scan were taken 5 months after bone grafting, and a screen capture of the virtual tooth setup and position of implants respecting the adjacent roots obtained (Figure 5). A palatal view screen capture showed the planned implant and screw access positions. The digital workflow enabled highly precise treatment planning for implant placement, avoiding closely adjacent anatomical structures. In addition, virtual implants, abutments, and restorations can be ‘placed’ to view resulting emergence profiles and the restorative result.

The digital workflow also includes the creation of milled or printed models, and printed surgical guides allow for precise creation of osteotomies for implant placement, since the surgical guide’s osteotomy window is printed based on the results from the implant planning software. In addition to precision and the opportunity to create custom healing abutments, the digital workflow offers increased efficiency and a better patient experience. For example, scan flags and optical scanning can be used instead of using traditional copings, impressions, and poured models with analogs. In the case shown here, scan flags constructed of a titanium base and PEEK (BioHorizons) were positioned over the implant and verified with radiographs to ensure they were properly seated (Figure 6). Optical intraoral scans were then taken. These are interpreted by CAD software, which creates a 3D digital model. The files can then be transferred digitally to the laboratory for restoration fabrication, which can be performed using the 3D digital model and CAD software, or a milled/printed model for traditional restoration fabrication. Scan flags enable high-precision intraoral optical scanning whereby the digital images accurately record the implant fixture, peri-implant mucosa, and adjacent structures. As a result, efficiency and accuracy are greater, and the patient avoids a traditional impression.

Milled custom healing abutments and custom abutments are also created using the digital workflow and CAD/CAM software, as well as milled models for provisional fabrication and CAD/CAM or milled models for fabrication of the definitive restoration (Figure 7).

The digital workflow has made implant treatment more precise and predictable, in addition to streamlining treatment and improving overall efficiency.

The case below demonstrates the digital workflow for single implant therapy in the anterior esthetic zone.

Case 1. Single implant restoration replacing the upper left lateral incisor

The patient presented with a fractured upper left lateral incisor that was deemed hopeless (Figures 8, 9). Together with
the patient, it was decided that the best option was extraction, immediate implant placement, and temporization. Ideal planning mandated the use of a CBCT scan. The digital workflow continued with the use of implant planning software (3Shape) for assessment of bone volume and quality, adjacent structures, and position of a virtual implant. The initial planning was for immediate implant placement of a 4.6 × 15 TLXP implant (BioHorizons) in order to allow for apical bone engagement for primary implant stability. However, using the implant planning software, the probability of leaving less than 2 mm of facial bone was identified (Figure 10). This would be undesirable and could result in future postrestoration instability of the facial and gingival tissue, with compromised esthetics. As a result, treatment was replanned for a 3.8 × 18 TLX implant (increased length, reduced diameter) (Figure 11). This would allow for primary implant stability, improved facial bone volume for long-term tissue contour stability, and improved positioning relative to the virtual tooth contour bucco-lingually.

After the ideal implant position was determined, the digital workflow allowed for alignment and printing of a surgical guide with inspection windows to verify full seating and color-coding for the planned implant and incorporating sleeves to aid precision during the osteotomy (Figure 12). Printed surgical guides have been shown to have a high degree of accuracy. Printed models were also created that would be used to fabricate components for temporization. A broad range of transitional restorative options can be preplanned to adapt to the unique features of the clinical environment. These include prefabricated, customized, healing abutments that can be coupled with a bonded nano-ceramic or PMMA bridge, and a transitional implant crown/engaging titanium base and seating jig where stability and occlusion permit. While engaging abutments are generally used in single restorations, non-engaging bases can be used to allow for prefabricated one-piece provisional restorations to overcome the problem of vertical implant positioning (timing) in a guided protocol.

Customized healing abutments allow for ideal soft tissue guidance and protection of underlying bone or bone graft materials in immediate implant placement. Adjacent natural teeth are predictive of papillary development and maintenance, and the distance from the bone level to the contact point with
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the adjacent tooth must be preplanned to foster papillary fill.\textsuperscript{10,11} Greater facial-lingual mucosal width at the base of the complete papillae also results in more complete papillae. These factors again highlight the desirability of precision planning, as offered by the digital workflow.

In this case, a customized PMMA healing abutment on an engaging titanium base was used that had been prefabricated with 3D information from the STL and DICOM files taken at the planning stage. The implant and healing abutment were verified radiographically postsurgery, and a bonded bridge was used for immediate temporization (Figures 13–15). Once peri-implant soft tissue is subject to remodeling as with a custom healing abutment/provisional restoration, it has been shown that papillae will regenerate when both one-stage and two-stage surgical protocols are maintained.\textsuperscript{12} Conservative surgical treatment was possible (extraction, implant placement, and bone grafting of the facial residual horizontal bone defect, custom healing abutment), resulting in uneventful soft tissue healing.

After soft tissue remodeling, the tissue contour was ideal, and a custom zirconia abutment was digitally designed and milled. Custom zirconia abutments result in superior esthetics and avoid the gray shine-through of metal abutments that may
be observed at gingival margins. The margin was also designed to be 0.5 mm subgingival to mirror the marginal gingival tissue defined by the healing abutment. A screw-retained lithium disilicate crown was milled from a digital model, and placed (Figures 16, 17). The result was an esthetic restoration that mimicked nature, and a satisfied patient.

Conclusions

Implant therapy is now mainstream and frequently the treatment of choice. In the anterior aesthetic zone, the emergence profile must allow for excellent esthetics, and the final restoration must mimic (or improve on) nature in addition to being functional. The advent of CBCT scans, digital impressions and the digital workflow has made treatment more precise and predictable. Virtual implant planning supports a restorative-driven approach with improved esthetics and function. The digital workflow also streamlines treatment with fewer appointments, and is more efficient overall, resulting in time and cost savings. It also allows the clinician and laboratory technician to share the same 3D images and treatment planning tools, improving communication, planning, and actual treatment.

References

1. Clinician and patient expectations dictate that treatment planning consider the ________ aspect of implant therapy.
   a. quantification
   b. anatomical, functional, and esthetic
   c. volumetric and anatomic
   d. perspective

2. To avoid causing abnormal loading of an implant, these can be placed ________ to compensate for inadequate bone volume.
   a. at an angle
   b. counter-rotationally
   c. subgingivally
   d. none of the above

3. Factors influencing patient satisfaction with esthetics include the ________.
   a. use of masking techniques
   b. amount of papillary fill
   c. number of teeth remaining
   d. color of the gingivae

4. Cone beam computed tomography (CBCT) used to obtain 3D digital images has resulted in significant improvements in planning and diagnostic capabilities.
   a. True
   b. False

5. Implant planning software creates virtual models to visualize a virtual implant in the arch using 3D images and ________ views.
   a. diagonal
   b. trans-sectional
   c. cross-sectional
   d. mirrored

6. Implant planning software permits an overview of the emergence profile and restorative result.
   a. True
   b. False

7. The osteotomy window in a printed surgical guide is printed based on the results from ________.
   a. a visual assessment
   b. the clinician’s assessment of the CBCT scan
   c. implant planning software
   d. a and b

8. ________ avoid the use of traditional copings, impressions, and poured models with analogs.
   a. Scan flags and CBCT scans
   b. Abutment flags and optical scanning
   c. Visual scanning and scanned flags
   d. Scan flags and optical scanning

9. Optical scans are interpreted by ________, which creates a 3D digital model.
   a. implant planning software
   b. CAD software
   c. CBCT software
   d. CAM software

10. ________ record the implant fixture, peri-implant mucosa, and adjacent structures.
    a. Analogs
    b. Healing abutments
    c. CBCT scans
    d. Scan flags

11. Milled custom healing and definitive abutments are created using the digital workflow and CAD/CAM software.
    a. True
    b. False

12. Leaving less than 2 mm of facial bone could result in postrestoration instability of the ________.
    a. facial and gingival tissue
    b. restoration
    c. facial and palatal bone
    d. all of the above

13. Inspection windows are included in surgical guides to verify ________.
    a. the position of the osteotomy
    b. full seating of the guide
    c. the width of the osteotomy
    d. the implant position

14. Where ________, permit, a transitional implant crown/engaging titanium base and seating jig can be used for provisional restorative care.
    a. stability and emergence profile
    b. occlusion and esthetics
    c. stability and occlusion
    d. esthetics and peri-implant mucosal tissue

15. Non-engaging abutments are generally used for single restorations.
    a. True
    b. False

16. The distance from the bone level to the contact point with the adjacent tooth must be preplanned to foster ________.
    a. emergence profile
    b. the health of peri-implant mucosa
    c. papillary fill
    d. a naturally shaped crown

17. 3D information from the ________ files are taken at the planning stage.
    a. STL
    b. jpeg
    c. DICOM
    d. a and c

18. Custom zirconia abutments ________.
    a. are stronger than traditional abutments
    b. avoid gray shine-through
    c. are recommended to improve soft tissue development
    d. all of the above

19. One reason a digital workflow makes treatment easier for patients is because ________.
    a. treatment is slower
    b. traditional impressions are not required
    c. x-ray exposure is not required at any point in treatment planning
    d. fewer locals are required

20. The digital workflow ________.
    a. streamlines treatment with fewer appointments
    b. is efficient
    c. results in time and cost savings
    d. all of the above
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CE ANSWER FORM (E-mail address required for processing)

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COURSE EVALUATION

1. Clarity of objectives: A B C D
2. Usefulness of content: A B C D
3. Benefit to your clinical practice: A B C D
4. Usefulness of the references: A B C D
5. Quality of written presentation: A B C D
6. Quality of illustrations: A B C D
7. Clarity of quiz questions: A B C D
8. Relevance of quiz questions: A B C D
9. Rate your overall satisfaction with this course: A B C D
10. Did this lesson achieve its educational objectives? Yes No
11. Are there any other topics you would like to see presented in the future? ______________________________________

EDUCATIONAL OBJECTIVES

1. Describe key factors in implant treatment planning;
2. Review the digital workflow and the use of digital setups in implant treatment planning;
3. Outline implant components that can be viewed virtually; and,
4. Describe CAD/CAM digital technology as part of the digital workflow and its use for printed and milled components used during implant therapy.

COURSE SUBMISSION:

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