Integrated treatment workflow
Diagnostics, treatment planning and
guided surgery with NobelClinician®
and NobelGuide®

Science First

Contents

Achieve predictable results in less time

Successful implant-based oral rehabilitation requires accurate preoperative surgical and prosthetic planning involving all members of the surgical and prosthodontic teams. Cross-sectional imaging, careful diagnosis and treatment planning enhance the identification and localization of anatomical structures and boundaries.[1,2] As such, they may preempt complications.

Full integration of all therapeutic steps

Today, digital workflows allow full integration of therapeutic steps from patient diagnostics and treatment planning to surgery and prosthetic design. The workflow with NobelClinician, for example, begins with patient assessment and treatment planning. It assists with diagnosis and evaluation of treatment complexity at the beginning of the treatment process. At the same time, the software establishes a common platform that allows the sharing of digital data and consultations among all involved team members such as the surgeon, the restorative dentist and the dental technician. This enables clinicians to successfully plan and implement treatment and to give patients detailed information about the intended procedures and estimated costs.

Increased efficiency

So far, guided protocols have relied on the acquisition of two 3D datasets: one scan of the patient wearing a radiographic guide and a second extraoral scan of the radiographic guide alone. These two datasets are then aligned by the software using radiographic markers in the guide. While this double-scanning procedure remains state-of-the art for edentulous patients, a streamlined digital workflow that does not require fabrication of a radiographic guide has recently been developed for partially edentulous patients. Accurate surface data obtained from a NobelProcera 2G Scanner can now be added to the treatment plan at any stage through the precise, fully automated NobelClinician SmartFusion technology.

Integrated treatment workflow

The integrated treatment workflow connects (CB)CT scanner, NobelClinician Software, the NobelProcera 2G System, NobelGuide and OsseoCare Pro to provide a seamless process from diagnosis to surgery and restoration.

1 Clinical examination and data acquisition
Direct import and fusion of the patient's (CB)CT scan and NobelProcera 2G scans of model and diagnostic tooth setup in NobelClinician Software.

2 Treatment planning
Accurate planning with NobelClinician Software based on the patient's anatomy and prosthetic requirements, including effective patient communication with the NobelClinician Communicator app.

Fusion of hard and soft tissue information

The main advantage of the integrated treatment workflow is the fusion of hard and soft tissue information. Soft tissue surface information obtained from NobelProcera 2G scans of the patient's cast can be combined with the radiographic data of the patient's jaw anatomy at any time during the planning process using a proprietary algorithm. A prosthetic tooth setup, created manually in a dental lab on the dental cast, can also be surface scanned and aligned to facilitate prosthetic-driven implant planning. Merging of these datasets allows the clinician to examine the radiographic scan data, the digitized surface scan of the treatment model and the diagnostic wax-up in one view and without the need for a radiographic guide. In the near future, technical developments will make it possible to directly import digital surface data generated by intra-oral scans.

Accurate surgical templates

A surgical guide for use in implant treatment is fabricated based on the patient's anatomy and the planned implant positions. Precision-fitting tooth- and/or mucosa-supported surgical templates are automatically generated using the integrated surface scan and planned implant positions. Accurate conversion of scan data is crucial for the physical production of the precisely fitting surgical template. To ensure accurate imaging segmentation of the radiographic guide, Nobel Biocare has developed a calibration procedure using a unique calibration object. The known contours and dimensions of this high precision object are matched to the scan data obtained with any (CB)CT system to calibrate the full workflow. This object adds to the precision of the stereolithographic fabrication of the NobelGuide surgical template.[138]

Minimizing digitization errors. The calibration object is scanned with a (CB)CT scanner and the resulting scan is compared with the original 3D surface using a calibration algorithm. The result of this calibration is an "optimized threshold" for which the digitization error is minimal. This threshold is used afterwards in the calibrated segmentation step in which a 3D surface model of a scanned radiographic guide is computed.

3 Guided surgery

Precise implant placement with custom-manufactured NobelGuide surgical templates for guided pilot drilling or fully guided implant insertion. Surgical steps can be automatically set up in the drill unit OsseoCare Pro based on the NobelClinician treatment plan.

4 Prosthetic restoration

Design and production of individualized CAD/CAM restorations with the NobelProcera System – for high precision of fit and natural esthetics.

Choice between pilot and fully guided drilling
In addition to the traditional fully guided approach, NobelGuide also offers options for guided pilot drilling. Initial drill positioning, orientation and the depth of the first drill during the implant site preparation are crucial steps. The NobelGuide pilot drill template helps to overcome this challenge by setting the preplanned drilling trajectory and depth while still enabling clinicians to finish the surgery using freehand techniques.

NobelGuide treatment workflows
NobelGuide offers pilot drilling and fully guided implant insertion for both completely and partially edentulous patients.

Partially edentulous patients	Edentulous patients
SmartFusion technology	Double-scan protocol with radiographic guide

1 Clinical examination and data acquisition

(CB)CT scan	Prosthetic setup scan		Radiographic guide
			↓
			(CB)CT double scan

2 Treatment planning

Planning with NobelClinician Software	Planning with NobelClinician Software

3 Guided surgery

Ordering of surgical template in NobelClinician Software	Ordering of surgical template in NobelClinician Software

Guided pilot drilling and freehand surgery	Fully guided surgery	Guided pilot drilling and freehand surgery	Fully guided surgery

Efficient collaboration

The use of NobelClinician in a team approach fosters labora-tory involvement and prosthetically driven treatment. Accu-rate surface model data, including from an optional wax-up, can be added into the planning process at any stage. Together with the freedom to decide on guided surgery during the course of planning, this offers clinicians improved flexibility in treatment management.

Treatment plans can easily be shared with collaborators or referring clinicians using the NobelClinician Communicator app, as well as with the patient to assist in understanding the planned treatment. Once finalized, the treatment plan can be uploaded from NobelClinician to the iPad®-operated OsseoCare Pro drill unit with one click.

Reduced overall costs

Studies evaluating the cost efficiency and treatment time of different treatment workflows are scarce. In a single study, a digital workflow has been shown to be more efficient than the conventional pathway. Both mean chair time and overall treat-ment costs are significantly lower for the customized restora-tions produced with a digital workflow compared with the conventional treatment pathway.[127] More research is needed, however, to substantiate that digital workflows reduce treat-ment time and increase cost efficiency.

Clinical case with fully guided surgery

Clinical situation

Patient presented with request for dental implant treatment subsequent to orthodontic therapy. Gingival tissues were healthy, and hard- and soft-tissue morphology was within normal limits. Periapical and CBCT radiograph revealed loss of most of the root structure. The four maxillary incisors were considered hopeless.

Diagnostics and treatment planning

Bone morphology in the area of interest was intact with continuous scalloping of the osseous crest, along with adequate bone height and width to receive implants. It was planned to place four adjacent implants at the time of extraction, with immediate provisionalization and subsequent restoration with single crowns.

Implants were planned relative to the final tooth position. NobelActive NP implants were selected for the lateral incisors and NobelActive RP implants for the central incisors. The implants were placed within the virtual environment taking into account the future free soft tissue margin. A surgical template for fully guided implant placement was ordered and used to position the analogs within the cast.

Preoperative periapical radiograph and sagittal CBCT view. Showing the extent of root resorption, palatal inclination and adequate volume of osseous structures.

Treatment planning. Modified cast after removal of the maxillary incisors (top left). Diagnostic wax-up of the final restoration (top right). View after SmartFusion. Volume rendering of CBCT scan and scan of cast outlining the soft tissue (bottom left). Visualization of the diagnostic wax-up in the same projection image (bottom right).

Virtual implant placement. Implant analogs added to the cast. Zirconia abutments were placed, and temporary restorations were fabricated for immediate delivery at the time of surgery (bottom right).

Implant insertion and immediate provisionalization

Immediately after atraumatic tooth extraction, the surgical template was seated. The lateral implant sites were prepared first. After seating of the lateral implants, the central incisor sites were prepared and the implants inserted. Implants were placed in a flapless surgery.

Provisional and final restoration

Zirconia abutments were seated and tightened with the recommended torque and temporary single crowns were tried in and splinted. Postoperative periapical radiographs showed precise implant placement. Prefabricated screw-retained final restorations were manufactured. Soft tissue architecture and health were maintained throughout treatment.

Case from: Wöhrle PS. Predictably replacing maxillary incisors with implants using 3-D planning and guided implant surgery. Compend Contin Educ Dent. 2014;35(10):758-68.

Fully guided surgery. Implant insertion using a fully guided surgical template (top left). Implants in situ after removal of the insertion assembly (top right). Provisional restorations (bottom left) and post insertion radiographs (bottom right).

Stable bone levels and soft tissue architecture. Two-year post-insertion radiograph and two-year post insertion clinical view.

Clinical case with pilot drilling

Clinical situation
Patient presented with vertical tooth drift of the four lower incisors, Angle Class II Division 1 dento-skeletal malocclusion, chronic periodontitis, tooth mobility and dental caries. The slow super-eruption of the lower incisors was followed by super eruption of the alveolar bone, resulting in maintenance of the bone levels.

Diagnostics and treatment planning
The NobelClinician Software visualizes patient anatomy, soft tissue surfaces and the planned prosthetic outcome, simplifying the assessment of the failing super-erupted dentition and of the final restoration contours. With this prosthetically driven approach immediate implant placement in the fresh extraction sockets is planned, with proper positioning to support imme-diate provisionalization. Two NobelParallel Conical Connection NP implants were planned in the 31–41 positions to overcome the issues related to the tight restorative space and the con-verging position of the canine roots. A pilot drill template was designed accordingly.

Clinical situation. Clinical view (left) and radiograph (right) at presentation.

Treatment planning. Visualization of patient anatomy and planned prosthetic outcome in NobelClinician Software.

Template design. Surgical template for pilot drilling and freehand surgery.

Implant site preparation and implant insertion

Immediately after tooth extraction, two implant sites were prepared with a pilot drill template. Implants were placed in a flapless surgery. A socket augmentation procedure was performed to enhance proper healing of the fresh extraction sites. No countersinking and no screw tapping procedures were performed. As planned, the implant platform was placed 1.5 mm below the most apical portion of the bone crest. No soft tissue grafting was performed.

Provisional and final restoration

A prefabricated screw-retained provisional restoration was immediately placed. For the final restoration, a NobelProcera Implant Bridge Zirconia was manufactured. After a healing period of five months, the soft tissue architecture resembles the scalloping of the gingival tissue around the natural dentition and its morphology mirrors the preserved bone morphology.

Case courtesy of Prof. Alessandro Pozzi, DDS, Rome, Italy

Implant site preparation and implant insertion. The pilot drill template was properly seated immediately after tooth extraction (left). Two NobelParallel Conical Connection implants were inserted (right).

Provisional restoration. View of the provisional restoration on a model (left). Intra-oral radiograph at delivery of provisional restoration (right).

Final restoration. Clinical view and intra-oral radiograph six months after implant placement.

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Diagnostic imaging in clinical practice

Numerous scientific papers have demonstrated the crucial role of cone beam computed tomography (CBCT) imaging in the field of implant dentistry, resulting in it being recommended as the preferred method of presurgical assessment of intra-oral implant sites in a position statement by the American Academy of Oral and Maxillofacial Radiology in 2012.[8] Its ability to visualize the smallest bony details means that CBCT is superior to CT for evaluating the morphology of the residual alveolar ridge and bone quantity in most cases, while emitting very low doses of radiation. The data can then be used in dedicated CAD/CAM software. Finally, the relatively low cost of CBCT systems makes them economically viable – even more so than conventional CT – for use in everyday clinical practice.

CBCT imaging as preferred method

Until recently, radiographic modalities for diagnosis during implant treatment planning relied upon two-dimensional projections of three-dimensional anatomical structures.[9,10] With the advent of computed tomography, cross-sectional imaging had evolved from simple, locally produced tomographic sections to more accurate, faster and more versatile 3D reconstructions computed for maxillofacial diagnostic tasks. However, this came at the cost of relatively high exposure doses. By the late 1990s, CBCT further advanced the field of dental and maxillofacial radiology by allowing 3D visualization of anatomical structures and their spatial relationship with a significantly reduced radiation exposure to the patient.[11,12] In contrast to the fan-shaped beams and multiple detectors used in multislice CT (MSCT), CBCT uses a conical X-ray beam to acquire images.[8] The entire volume is imaged in one single rotation using a flat two-dimensional image receptor.[11,13-18] It is therefore no surprise that CBCT imaging is recommended as the preferred method of presurgical assessment of intra-oral implant sites by the Academy of Oral and Maxillofacial Radiology.[8]

High accuracy and patient satisfaction

The past decade witnessed a paradigm shift from surgically driven to prosthetically driven implant placement planning. No longer just an add-on to the process, CBCT scanning has become the cornerstone of an integrated treatment workflow, helping clinicians better execute their treatment plans. With a single scan, practitioners are able to acquire much more – and more accurate – data at low effective radiation doses that are nearly equivalent to the dose of panoramic exams. The superior radiographic visualization compared with 2D radiography[1] allows for a better presurgical assessment and a better understanding of any oral pathologies. At the same time, the data can be used to optimize virtual treatment planning in 3D and to prepare for guided surgery, which contributes to optimized, tailored treatment for each patient.

Furthermore, less invasive procedures reduce patient discomfort[19,124,125] and result in high patient satisfaction, as shown in observational studies on guided flapless surgery.[20,21,134] Ultimately, they also lead to better restorative outcomes.[22] A recent study to assess prospective implant sites using panoramic radiography versus panoramic scans combined with CBCT imaging revealed that CBCT increases the accuracy of treatment planning in predicting the actual implant dimensions required at surgery. Performing a CBCT scan during the planning phase increases the agreement in predicting implant length considerably, from 40% after the initial 2D scan to 69.5%.[23] The overall outcome is a more predictable surgical and restorative result.

CBCT scan imported into NobelClinician Software. CBCT scanning has become the cornerstone of an integrated treatment workflow helping clinicians better execute their treatment plans.

Imaging modalities recommended by The American Academy of Oral and Maxillofacial Radiology

Preoperative planning	Postoperative implant assessment
Initial evaluation Panoramic radiograph, followed by intra-oral radiographs to obtain supplemental information. Use of cross-sectional imaging discouraged.	**Immediate post-op evaluation** Intra-oral radiographs are recommended in the absence of clinical signs or symptoms. Cross-sectional imaging (particularly CBCT) should only be used immediately postoperatively if the patient presents with implant mobility or altered sensation.
Radiographic exam of implant sites Include cross-sectional imaging orthogonal to the site of interest. CBCT considered the imaging modality of choice.	**Follow-up examination** CBCT to be considered if implant retrieval is anticipated. Should not be used for periodic review of clinically asymptomatic implants. Instead, intra-oral and, in some cases, panoramic images are adequate for postoperative implant monitoring.
Bone augmentation CBCT if augmentation procedures or site development before placing dental implants are required, and if bone reconstruction and augmentation procedures have been performed prior to implant placement.	**Statement on the use of CBCT for research purposes** Applicable to all scanning procedures. Adhere to the principle of keeping radiation doses **A**s **L**ow **A**s **R**easonably **A**chievable (ALARA).

Adapted from Tyndall et al. (2012)[8]

Superior visualization of anatomical structures

Digital imaging offers clinicians and technicians a highly accurate diagnostic and treatment planning tool with the potential to reformat the scan data and create virtual models of the patient's anatomy. There is also the distinct advantage of accurate measurement in any dimension, even along a curved line.[24] The generated 3D volumetric data sets are essentially distortion-free and can provide primary reconstruction images in multiple planes. One of the main characteristics of CBCT is the ability to depict the fine details of bony structures. It is therefore particularly suited to head and neck diagnostics and dental applications in order to:

– Assess the anatomy, available bone height, width, and relative quality for implant surgery planning and in the management of suspected implant treatment complications.
– Determine the three-dimensional topography of the alveolar ridge.
– Localize vital anatomical structures in close proximity to the planned surgery sites, i.e., the inferior alveolar nerve, mental foramen, incisive canal, maxillary sinus, sinus ostia and nasal cavity floor.
– Assess the presence of dento-alveolar pathology in the jaws and dentition or even temporomandibular joint (TMJ) pathology that was not adequately assessed using 2D radiographic techniques.[25]

The reliability of dimensional measurements is clinically relevant. Radiological data acquisition can lead to deviations from anatomical reality. These deviations, however, apply to all radiographs including panoramic x-rays. Even on dry skulls they led to underestimations of more than 1 mm in 24% of all measurements.[26] In a study with spiral tomographic images, derived from six fresh *ex vivo* skulls, overestimations and underestimations of the distance from the crest to the mandibular canal reached 1.05 mm and 1.36 mm, respectively.[27] Until recently, linear assessments of bone measurements in implant dentistry have been highly unreliable, given the limitations of 2D radiographs and conventional tomographic techniques that have inherent distortion. While CBCT has not only shown the ability to provide sub-millimeter measurements at much higher accuracy, it also provides segmentation accuracy that allows the creation of accurate 3D models.[2] In addition, CBCT imaging offers potential for implant follow-up, as it produces considerably less metal artifacts than MSCT.[28]

Parameters that affect radiation dose

In practice, higher resolution of bone structures can be obtained with CBCT than with MSCT. Radiation exposure from CBCT is typically considered to be lower than that incurred from common spiral and multislice protocols.[29-37] Depending on the geometrical configuration and the exposure parameters of the system, there is significant variability in the effective radiation dose delivered by CBCT machines. Dose reduction can be achieved by adjusting operating parameters. Crucial parameters include exposure time, tube current, the size of the field of view (FOV) and the angular degree at which the gantry rotates around the patient's head.[16,17,31,33,38-47]

Limited radiation with proper FOV adjustment

In accordance with the ALARA (as low as reasonably achievable) principle, the radiation exposure should be minimized to produce an image of the required spatial resolution and diagnostic quality.[48,49] Exposures should be carried out while selecting the appropriate exposure settings (kV and mA) and resolution (voxel), and most importantly with a proper adjustment of the field of view (FOV) to the actual region of interest, keeping the scan volume as small as possible.[48,49] Doses can even be further reduced by positioning the primary beam to avoid radiosensitive organs within the head and neck region.[50]

FOV 8 cm x 8 cm   FOV 16 cm x 4 cm   FOV 16 cm x 6 cm upper jaw TMJ

FOV 16 cm x 6 cm lower jaw   FOV 16 cm x 8 cm   FOV 16 cm x 10 cm

FOV 16 cm x 11 cm   FOV 16 cm x 13 cm   FOV 23 cm x 17 cm

ALARA. Adjusting the FOV is crucial for minimizing radiation exposure (adapted from Ludlow and Walker 2013).[51]

Minidose CBCT units

Effective radiation doses of dento-alveolar CBCT scans range from 19 to 674 µSv depending on the type of scanner, the FOV, the scan resolution and the anatomical region being examined (effective doses according to ICRP 2007). Those incurred from CT scanning range between 280–1410 µSv.[29] For comparison, the effective dose from one panoramic radiograph is approximately 3 to 24 µSv and that of a complete series of intra-oral radiographs can range from 20 µSv to 40 µSv.[29] Meanwhile, the average natural background radiation is 2400 µSv (2.4 mSv) per year or 6.6 µSv per day.[29] CBCT units delivering the lowest doses are nearly equivalent to the dose of panoramic exams, allowing clinicians to benefit from the power of 3D imaging while limiting the risk associated with radiation exposure. Novel fast scanning protocols are expected to further reduce effective radiation exposures. Lately, MSCT has also been adjusted to allow low dose protocols for maxillofacial applications without diminishing image quality, but more research is needed to define adequate protocols for sufficient image quality.[52-57]

Minidose CBCT units deliver radiation doses that are nearly equivalent to those of panoramic exams

Imaging modality	Effective dose (µSV)
Intra-oral radiograph	
Single radiograph*	< 2
Full mouth survey (20 radiographs)	20–40
Panoramic radiograph	3–24
Lateral "profile" radiograph	< 6
Conventional tomography	47–88
CBCT	
Dento-alveolar§	19–674
Craniofacial§	30–1073
Minidose solutions#	4–32
Computed tomography	280–1410

Adapted from Harris et al. 2012[29]

* Assumes use of F-speed film or photostimulable phosphor plate with rectangular collimation. The use of slower film (D and E speed) and round collimation substantially increase the dose.

§ The height of the dento-alveolar FOVs is smaller than 10 cm allowing imaging of the lower and upper jaws. For the craniofacial FOVs, the height is greater than 10 cm allowing maxillofacial imaging. FOVs of minidose solutions range from 5×5 to 13×15 cm.

From Ludlow and Walker 2014.[51]

Individual diagnostic task defines imaging protocol

The most important requirement for dentomaxillofacial diagnostic imaging is high spatial resolution for 3D depiction of detailed bony structures. A balance is needed between the image noise, a lower contrast of lower exposures and the higher resolution gained from prolonged radiation exposure, which is associated with movement artifacts. Furthermore, streaking imaging artifacts caused by metallic crowns or dental restorations interfering with the visualization of the region of interest are reduced compared with a multislice CT.[58] As a result, imaging protocols have to be carefully adapted to the individual diagnostic task.[36,42,43,59-63]

Limitations of CBCT scanning

CBCT produces images with sub-millimeter isotropic voxel resolution ranging from 0.4 mm to as low as 0.076 mm.[25] One significant limitation of CBCT is the relatively low contrast depiction of soft tissue structures. With the exception of the visualization of soft tissue outlines such as the pharynx, soft tissue CBCT imaging is difficult due to low contrast resolution.[24,64] Improved visualization of gingival contours and thickness can be achieved with established techniques such as the use of a lip retractor or a cotton roll to separate the lips from the vestibulum.[65]

It is also important to note that displayed gray levels in CBCT systems are arbitrary and do not allow Hounsfield Unit (HU) measurement for the assessment of bone quality, unlike in MSCT.[66] HUs are relative quantifiers of the density of body tissues, e.g., of bone density. This can be clinically relevant for osteoporotic patients or when bone lesions are suspected on the images. However, considerable progress has been made to develop equally reliable systems for assessing radiologic tissue density using CBCT. A strong positive correlation exists between the bone density values provided by the system and the bone volumetric fraction, as assessed by micro-CT bone biopsies.[67]

CBCT superior to MSCT

The recent Swiss guidelines for the use of cone-beam computed tomography / digital volume tomography confirm the recommendation of CBCT over multislice computed tomography (MSCT) for implant therapy.[48] A wealth of evidence supports that CBCT generally requires a lower radiation dose for the same imaging task,[1,33,68,69] while better imaging quality can be achieved.[70,71] In addition, high reliability for distance measurements has been demonstrated.[72-76] As with any procedure, it is crucial to weigh the benefits against the respective and accumulated risks for each patient.

NobelClinician® – scientific evidence

With its SmartFusion technology, the NobelClinician Software combines 3D imagery of anatomical structures with soft tissue information from optical surface scans for precise visualization of the treatment situation. Data sets can easily be tilted or rotated allowing navigation through any anatomical structure. This improves diagnostics and treatment planning. NobelClinician also supports the design of templates for guided surgery and is directly linked to the NobelProcera 2G System. Its platform allows users to share digital data and consultations among all involved team members; and when used as a patient communication tool, it results in high treatment acceptance and patient satisfaction.[80,81]

Building on more than 20 publications documenting the performance of the original NobelGuide treatment planning software, seven publications report on clinical outcomes of more than 1750 implants planned with the NobelClinician Software in various indications.

Key findings
– Precise planning through virtual visualization of implant positions using clinical and radiographic data,[82,83] facilitating final decision making in implant prosthodontic treatment.[154]
– High treatment predictability through accurate assessment of available bone volume.[4,84,153,154]
– Optimized use of available bone, matching the implant design and the drilling sequence to bone quality for enhanced primary stability.[130]
– Increased options for minimally invasive treatment: widening indications where flapless surgery is feasible[117,123,124] and reducing the necessity of bone augmentation procedures.[4,84]
– Higher patient satisfaction with care and treatment outcomes using virtual treatment planning communication tool.[80,81]

The authors of studies comparing the clinical use of different implant planning and guided surgery systems describe NobelClinician/NobelGuide as an easier to use and more comprehensive implant planning and placement system for preparing osteotomies to the planned depth and angulation and for accurately performing guided implant placement of both straight and tapered implants.[139,151]

The first virtual planning system
Introduced in 2011, NobelClinician builds on its predecessor, the NobelGuide treatment planning software, which was the first virtual planning system based on the double-scan technique. Described in 1998, the double-scanning workflow and the 3D depiction of the CT or CBCT images with a layered prosthetic plan represented a major breakthrough for digital implant planning and preoperative patient assessment.[89] A comparative study proved that there is a better concordance in surgery outcome when planning with 3D images vs. 2D images.[90] In NobelClinician, the clinician views the 3D data set derived from (CB)CT scan data that consist of a series of transaxial images, orthogonally aligned to the patient's vertical axis and registered as one volume. By selecting slices in any plane, data integrity is always fully preserved, as no recalculation is involved. Scan data are stored and distributed in the standard DICOM (Digital Imaging and Communications in Medicine) format and can be easily analyzed and shared.

Effective visualization. SmartFusion technology visualizes the patient's CBCT data together with the intra-oral situation. The NobelClinician Communicator iPad® app supports effective patient communication.

Optimized implant positioning

With NobelClinician, the type and size of the planned implants, their position in the bone and relation to the adjacent teeth or implants, and their proximity to vital structures can all be accurately determined in advance of surgery. Furthermore, the planned restoration can be visualized to optimize both functional and esthetic outcomes. Katsoulis and colleagues evaluated prosthetically driven digital implant planning, reporting full control of the implant axis in relation to the prosthetic restoration and facilitated decision making for prosthodontic treatment.[154] Not only can the implants be positioned for an optimized surgical and restorative solution for the patient, Schnitman and Hayashi also observed that planning and optimization of the emergence profile resulted in favorable bone levels at the implant platform and good papilla formation between implants and between implants and teeth.[155]

Accurate planning for better safety

Digital treatment planning with NobelClinician has been shown to avoid overestimation of ridge thickness by as much as 50% and can capture ridge width differences in various regions of the jaw, which allows for a more accurate preoperative assessment of bone volume compared with clinical assessment.[153] This aids in identifying the optimal implant size and position prior to implant surgery.[83,90-93] Such detailed planning of the implant locations, diameters, lengths and angulations also helps to avoid iatrogenic injury, such as induced neurosensory disturbance to the inferior alveolar nerve.[96,97] Importantly, longer implants are associated with a higher risk of damaging vital structures, giving additional importance to the existence of safety margins within the treatment planning tool.[98] NobelClinician Software indicates the safety margin with a yellow halo around the implant.

Safe planning. NobelClinician Software warns users if an implant is placed too close to an annotated nerve or root (implant turns orange).

Accurate surgical templates

The accuracy of computer-guided implant positioning is defined as the deviation between the virtually planned implant position and the actual postoperative position of the implant. This total deviation represents the sum of all inaccuracies involved from data set acquisition to the surgical procedure.[94,95] An *in vitro* validation assessing the accuracy of surgical templates for fully edentulous patients compared the positions and orientation of the planned and the actual guide sleeves. The mean three-dimensional and angular deviation between the planned and the simulated implant location was 0.17 ± 0.08 mm and 0.67 ± 0.35°, respectively, while the average deviation at the apex of the 13 mm long implant was 0.32 ± 0.15 mm. These deviations represent the sum of inaccuracy introduced by the algorithm to generate the template, the production process, the insertion of the sleeves into the template and the manual fit of the template; they do not however assess the accuracy of the surgical execution.[85] These very small deviations in surgical template manufacturing are considered acceptable and clinically irrelevant as they are taken into account during treatment planning by the safety margins defined by the NobelClinician Software.

Accurate transfer of treatment plan into clinical reality

Prospective clinical studies have demonstrated that computer-assisted treatment planning can be reliably transferred into practice using guided implantation.[77,122] At implant shoulder level, the average horizontal deviations were 0.43 mm bucco-lingually, 0.46 mm mesiodistally, and 0.53 mm vertically. Slightly higher at the implant apex, they averaged 0.7 mm buccolin-gually, 0.63 mm mesiodistally and 0.52 mm in implant depth. All maximum deviations measured were within the safety margins recommended by the NobelClinician Software, confirming the validity of the safety margin. The clinical use of NobelGuide templates to place implants in the virtually planned positions results in accurate and predictable implant placement[82,83] and reduced post-operative morbidity compared with placement with freehand surgery.[19]

Minimally invasive treatments using all available bone

3D treatment planning has the potential to reduce the number of bone augmentation procedures prior to implant placement. Visualization of CT scan data with NobelClinician leads to significantly fewer bone reconstructive surgeries before implant placement in the atrophic maxilla and mandible compared with procedures using conventional manual measurements (p=0.004) and an autocad system (p=0.001).[84] The application of 3D planning following conventional panoramic oral exam has also shown that the latter overestimates the need for sinus lift procedures in over two thirds of cases.[92] 3D software also simplifies planning and insertion of tilted implants.[4,99] Finally, optimized visualization and treatment planning achieved with 3D software may help avoid perforations of the labial cortex of the jaws or of the lingual cortex in the distal areas of the lower jaw, which may otherwise occur if bone volume is overestimated. Minimally invasive treatment options, e.g., surgical procedures without sinus lift when clinically indicated, can become more widely available to patients with 3D planning software.[4] Minimally invasive treatment options in the context of guided surgery to minimize patient discomfort are further discussed on page 23.

Minimized challenges

In challenging situations, computer-assisted implant treatment planning together with guided surgery is highly effective. In patients with a gummy smile, for example, the NobelClinician Software was used successfully to plan an alveoplasty in the upper anterior maxilla, helping ensure that the prosthesis-soft tissue transition was masked by the upper lip.[102] Digital planning also allows guided surgery for transcrestal maxillary sinus floor elevation. Successfully used in a study with 66 patients, cumulative implant survival rate was 98.5% at three years and no prosthetic failures occurred during the follow-up period.[5] In another prospective trial, virtually planned guided flapless implant surgery was performed following major reconstruction after tumor resection or gunshot traumas.[101] Implant survival after four years was 94.6% and patients were highly satisfied with their newly gained masticatory function and overall quality of life. Authors report that digital treatment planning minimized the demanding surgical and prosthetic challenges when treating patients with major reconstructions.[101]

High treatment acceptance due to improved patient communication

Communication within the treatment team is crucial for optimizing treatment outcomes in complex multidisciplinary oral rehabilitations. Furthermore, effective patient communication can improve the patient's understanding of the treatment options available, increase treatment acceptance and raise their overall satisfaction with their care and treatment. [80,81] In a study with 31 patients needing implant- or tooth-supported restorations, two interactive patient communication sessions showing fused images on an iPad were held to engage patients in treatment planning, improve their understanding of the treatment, visualize the anticipated esthetic outcome and analyze the results.[81] Tailored pre- and post-treatment questionnaires assessed patient satisfaction with care and treatment outcomes. After the first interactive session, there was significantly higher agreement amongst patients that they were thoroughly informed about their oral health status and the planned treatment. After the second session recapping the overall treatment and visualizing the results, patients reported significantly higher satisfaction with treatment outcome.[81] At both time points, use of an interactive visual communication tool resulted in significantly higher patient satisfaction.

Higher patient satisfaction when NobelClinician is used as a visual communication tool[81]

p<0.05

	Before	After
Do not agree	34%	7%
Hard to say	22%	13%
Agree	44%	80%

Patients agree that they were better informed about their oral health status and planned treatment steps after the use of NobelClinician as a communication tool.

p<0.05

	Before	After
No	16%	5%
Do not know	9%	5%
Yes	75%	90%

Patients are more satisfied with treatment outcome after a discussion using NobelClinician visual tools to review the pre- and post-operative clinical pictures summarizing the clinical steps and highlighting the details of the restored region.

NobelGuide® – scientific evidence

NobelGuide was the first comprehensive concept for 3D treatment planning and guided surgery. It offers pilot drilling and fully guided implant insertion for both completely and partially edentulous patients. Use of NobelGuide in implant dentistry offers more accurate and predictable implant placement compared with freehand surgery and lays the foundation for excellent restorative outcomes. In addition, guided surgery allows streamlined implant placement and is associated with less discomfort for the patient.

More than 40 publications are available on the clinical application of NobelGuide, reporting on the use of over 5900 Nobel Biocare implants in more than 950 patients.

Key findings
– Higher accuracy and predictability of implant positions compared with freehand surgery.[107,108,131]
– Excellent cumulative implant survival rates (CSR) of 96.8% weighted mean in 38 studies with guided surgery technique in up to seven years of follow-up (see table on page 31).
– Significantly lower swelling, edema and pain[19,124] as well as use of analgesics[19,124,125] with guided flapless surgery compared with freehand surgery.
– Very high patient satisfaction[19,20,103-105] as well as subjective evaluation of masticatory function (VAS§ 99.2, SD 2.1, range 95–100) and esthetics (VAS 98.1, SD 2.9, range 90–100).[106]
– Good esthetic outcomes in the anterior maxilla, median pink esthetic score of 12 (IQR# 8.5-12.5).[87]
– Reliable transfer of the planned treatment to the patient with high accuracy of implant positions.[77-79,86-88,114,115,137]

Highly accurate implant placement
Even when presented on 3D images at the same inclination, the mental transfer of the implant orientation from the virtual plan to the supine patient remains approximate. Combining this digital planning with stereolithographic template-guided surgery enables significantly more precise implant placement, as it leads to smaller deviations in inclination/orientation, depth, entry point and location of the implant tip compared with freehand implant placement.[107,108,131] Guided surgery helps maintain the precision of the drilling axis mitigating patient movement during surgery. In a recent systematic review, template-guided implant placement showed a statistically superior accuracy when compared with freehand placement (see graph).[107]* Reliable accuracy is also reported in several *in vitro* approaches,[109,111] *ex vivo*[83,112] and *in vivo* studies using NobelGuide.[77-79,86]

Guided surgery is significantly more accurate than freehand surgery[107]

Freehand (n=868)
Fully guided (n=1011)

Systematic review shows significantly smaller deviations between the planned and actual implant positions in guided vs. freehand surgery.*

§ VAS: Visual Analog Scale from 1 to 100.
# IQR: Interquartile range.
* Although the review includes nine different guided surgery systems, the majority of the reviewed studies used NobelGuide.

Maximum deviations within safety margins

While the literature frequently focuses on average and global deviations, it is the maximum deviation in each direction that determines the risk to anatomical structures. Most clinical studies reporting on the accuracy of NobelGuide report the maximum deviation in the oro-vestibular, mesiodistal and vertical directions to be within the tolerance margins of 1.5 mm around the implant shoulder and 3 mm at the implant tip, i.e., within the safety zone recommended by the planning software (see graph).[78,79,86,88,137] In the single clinical study where maximum apical deviations largely exceeded the safety zone, implants were placed in augmented bone.[115] The authors had abandoned the use of pins in most cases and suggest that the drills may shift away at the transition of original cortical bone to the more spongious augmented bone.[115] In a subsequent study, the deviations were brought within the safety zone by using a technique to effectively stabilize the surgical template in second-stage implant placement using the screws from the first-stage bone augmentation surgery.[136] Template-guided implant placement is an accurate means of reliably transferring preoperative computer-aided planning into surgical practice if the protocols are observed.[77] The failure to maintain guide stability during surgery was deemed to be the greatest contributing factor to inaccuracy.[107,113]

Tooth- vs. bone- and mucosa-supported templates

The main variable that influences accuracy of template-guided implant placement is the type of template support. The lowest deviations are with tooth-supported templates, which show significantly lower deviations compared with bone- and mucosa-supported templates.[116] By contrast, bone-supported guides show significantly larger deviations than other types of guide support.[107] Templates with mixed tooth and mucosa support had higher mesiodistal deviations compared with purely tooth-supported templates. Mucosal resilience and distortion of the template were indicated as reasons for this finding.[83] Thickness of the mucosa in partially dentate and edentulous patients also impacts accuracy.[77] Increased mucosal thickness may affect reproducibility of template position and seating regardless of anchoring elements, especially for purely mucosa-supported applications.

Clinical studies measuring accuracy of digitally planned and guided surgery at implant apex*

*Most of the listed studies report only the maximum deviation. For the studies reporting both the minimum and the maximum deviation,[78,88,137] both values are depicted.

21

Great results and high suitability for a variety of indications

Early retrospective results with fully edentulous patients treated with flapless surgery and immediate loading reported a CSR of 98.9% at up to five years' follow-up when looking solely at the non-smoking patients.[121] Recent studies (2012–2015) with more than three years' mean follow-up using the current NobelGuide system report implant survival rates of 93.4–100% (see table). The NobelGuide system has been successfully applied in a variety of indications. A CSR of 98.8% was observed for immediate loading after guided flapless surgery in a one-year prospective multicenter study reporting on the use of NobelReplace Tapered implants in partially and completely edentulous upper and lower jaws.[122] In another study, 27 partially and fully edentulous patients were treated with flapless surgery and immediate full-arch or partial restorations on 160 implants. The follow-up time varied from 48 to 77 months and the CSR reached 97.3%.[7] In a prospective study on the All-on-4 treatment concept using NobelGuide (23 edentulous patients and 92 inserted implants), the CSR after five years was 96.6%.[118] When using NobelGuide and immediate loading the same survival rate is even reached in patients with fresh-frozen homologous bone. This 96.5% CSR at implant level was retrospectively shown at one to five years' follow-up of 65 patients receiving 342 implants to support 77 full-arch prostheses.[123] In a three-year multicenter study including 30 consecutive fully edentulous patients, 312 implants were inserted using NobelGuide with a flapless approach. Both jaws were treated at the same time, and prefabricated screw-retained fixed dental prostheses were inserted at the end of surgery. The implant CSR was 97.9%.[126]

Counterintuitively, guided surgery requires more training than freehand

According to the EAO consensus 2012, using a guided surgery technique requires greater skill and clinical experience than regular implant surgery.[116] In a single study students placed implants with a surprisingly low survival rate of 83.5% not seen in the literature on NobelGuide. Prosthetic survival in contrast was 100%. Experience is one of the multiple factors that were suggested to have played a possible role, as well as possible overheating caused by lack of irrigation during surgery.[142] With proper training, and when applied meticulously, the guided surgery approach using surgical templates with guide sleeves has proven to be very reliable.

Recent peer-reviewed studies using NobelGuide with more than three years' mean follow-up

Study	# implants/ # patients	Mean follow-up (years)	CSR %
Balshi et al. 2013[117]	136/NR	7.0	93.4
Orentlicher et al. 2014[129]	674/NR	7.0	96.7
Polizzi et al. 2015[7]	160/27	5.1	97.3
Lopes et al. 2014[118]	92/23	5.0	96.6
Schnitman et al. 2014[130]	80/27	4.2	100
Pozzi et al. 2013[119]	132/16	4.1	100
Pozzi and Moy 2014[5] [§]	136/66	3.7	98.5
Pozzi et al. 2012[4]	81/27	3.6	96.3
Pozzi et al. 2015[106]	170/22	3.5	100

§ With sinus floor augmentation

Results in line with meta-analyses

Comparative studies between different guided surgery systems are scarce and difficult to interpret because various factors need to be taken into consideration, e.g., radiological data acquisition, positioning of templates, surgical skills, familiarity with a particular system and unconscious bias.[111] Several systematic reviews and meta-analyses on the efficacy of different available systems for guided surgery have been published.[94,95,100,107] They report cumulative implant survival rates of 91% to 100% after observation periods of one to five years.[95] In a more recent review including 14 survival studies, the average implant survival rate after one year was 97.3%, the average prosthetic survival rate was 95.5%.[107]

Minimized patient discomfort with flapless surgery

Controlled studies comparing guided flapless with conventional open-flap surgery demonstrate a statistically significant reduction in immediate postoperative pain[19,124] and use of analgesics,[125] lower swelling and edema[19,124] and as a result lower morbidity,[124] with the flapless guided approach. In a prospective study, patients undergoing conventional surgery rated intensity of postoperative pain higher (VAS 47.2, maximum value 100). They required more analgesics and for a longer period, stopping two days later than patients treated using guided surgery (VAS 12.8).[125] A randomized trial showed that planned treatment goals were achieved by both, however postoperative self-reported pain and swelling were significantly lower in patients that had guided implant placement.[19] No significant differences were observed in implant or prosthetic outcomes, including survival, marginal bone level changes and complications. These results confirm the good scores for patient comfort and satisfaction reported by observational studies on patient groups treated with guided flapless surgery.[21,134]

Effective alternative to conventional sinus lift

Minimally invasive guided flapless placement of straight and tilted implants parallel to the anterior and posterior sinus walls by means of template-guided surgery may be an effective alternative to conventional maxillary sinus floor augmentation.[4] Pozzi and colleagues developed a novel technique referred to as flapless transcrestal guided sinus lift elevation. First described in a case report, the depth of the expanded-condensing osteotome was digitally planned to puncture the bony sinus floor and the Schneiderin membrane was raised without perforation.[128] Follow-up of 66 partially edentulous patients demonstrated a CSR of 98.5% and mean marginal bone level change of -0.51 mm after three years. No complications occurred and all bone grafts were successful with patients reporting low levels of pain.[5]

Clinical case – digital treatment planning and flapless guided surgery[19]

a) Preoperative view of partially edentulous patient in the posterior mandible.
b) Implant positioning according to prosthetic requirements.
c) Surgical template with the three implants placed flaplessly.
d) Ideal inter-implant and tooth-implant distances and soft tissue health.
e) CAD/CAM zirconium dioxide screw-retained final restoration in situ.
f) Intra-oral radiograph after one year in function.

Successful outcomes with immediate loading and immediate implant placement

NobelGuide guided surgical approach with immediate loading has become a well-documented treatment option.[19,103,106,117-123] A randomized trial demonstrated lower bone remodeling when applying an immediate compared with a delayed loading protocol.[19] In a three-arm study Balshi and colleagues showed significantly lower survival outcomes for implants placed freehand with a six to eight month healing period compared with immediately loaded implants placed either freehand or fully guided, with no significant difference between the two immediate loading groups.[117] Prefabrication of the final prosthesis during digital treatment planning was performed in the first studies on NobelGuide with immediate loading.[20,118,120,121,146,149,150,155] To avoid prosthetic complications seen in early studies in which the final prosthesis was fabricated already during planning,[120,146,150,156] it is recommended that the final restoration be prepared based on actual implant impressions taken at the time of surgery.[156] Observation of the tissue response to the provisional restoration can also give the restorative dentist invaluable information regarding the gingival contours and esthetics in preparation for the final restoration.[154]

Protocols with NobelGuide have further allowed for immediately loaded implants placed in extraction sites. Two-year results for 12 consecutive patients with 26 of 72 total implants placed in extraction sites filled with bone graft material, covered with a membrane and immediately loaded, showed 100% implant and prosthetic survival rates.[133] Biological complications were limited to inflammation around post-extraction implants at three months which was resolved with oral hygiene measures. Polizzi and Cantoni (2015) directly compared outcomes of guided surgery for implant placement in healed and extraction sites.[7] At all time points, there were no significant differences in bone remodelling or implant CSR between the implants placed in healed and extraction sites. These results demonstrate the feasibility of guided surgery for placing implants in fresh extraction sites.

High patient satisfaction and excellent esthetics

Using a digital workflow for implant planning and the prefabrication of prosthetic superstructures has a positive influence on esthetic outcomes. One of the first to document this was van Steenberghe and colleagues in their prospective multi-center study on 27 consecutive patients with completely edentulous maxillae. These patients received individualized CAD/CAM bridges at the end of the flapless surgery. At year one, the esthetics were scored by the clinicians as excellent (n = 18), good (3), acceptable (2) and non-acceptable (1). The single un-acceptable outcome was assigned due to a midline deviation of the prosthesis in this patient. A quality of life (QoL) assessment was performed at three months' follow-up. Patients were highly satisfied with regards to speech, function, esthetics and sense.[20]

High physician rating of esthetics and function

Functional and esthetic outcomes with individualized CAD/CAM bridges derived from digital treatment workflow one year after treatment.[20]

Patients report a high increase in quality of life

27 patients assessed speech, function, esthetics and sense on a visual analog scale (VAS) from 1–10 (10 being optimal outcome). They reported a high increase in quality of life during the first three months after implant treatment and were highly satisfied with both functional parameters and esthetics. (Illustrations adapted from van Steenberghe et al. 2005)[20]

In another prospective study, socket grafting was followed by implant placement in the esthetic zone of the maxilla in 25 patients using virtual treatment planning software and stereolithographic templates. Satisfactory implant esthetics were achieved in 71% of patients (compared with 56% after bone augmentation procedures involving mucoperiosteal flap). Papillae were preserved to their full extent in 77% of patients (compared with 13% after conventional two-stage surgery).[22] The same group revealed that flapless surgery shows significantly better results regarding mesial papilla presence (89% vs 57%, p<0.001), distal papilla presence (81% vs 61%, p=0.010), as well as natural soft tissue contour (67% vs 43%, p=0.004).[87]

Short overall treatment time

Depending on the clinical circumstances and the experience of the clinician, digital treatment planning and guided surgery can be used to successfully treat partially and fully edentulous patients by placing implants in extraction or healed sites, in either single-stage or two-stage approaches and with or without mucoperiosteal flap elevation. While more time is invested in the planning up front, there are savings in terms of overall treatment time.[154] Surgical time for flapless surgery can be as low as 14.9 minutes up to a maximum of 34 minutes (mean 22.9, SD 4.7 minutes).[134] Overall treatment time can be reduced considerably. For single-stage procedures with immediate loading, patients may be fully rehabilitated with a provisional prosthesis within 48 hours.[4,7,106,118] Using a digital treatment planning and guided surgery approach patients experience less surgical trauma, pain and swelling,[19,125] recovery time is reduced,[5,20,139] and therefore their return to their normal lives is expedited.

Computed-tomography-based evaluation of template (NobelGuide)-guided implant positions: a prospective radiological study

Vasak C, Watzak G, Gahleitner A, Strbac G, Schemper M, Zechner W
Clin Oral Implants Res. 2011;22:1157-1163

A Implant shoulder (mm)

B Implant apex (mm)

n = 79

Box plot of the deviations determined at the level of the implant shoulder (A) and the implant apex (B) along x, y and z-axis.

Box plot illustrations of the deviations obtained along the x, y and z-axis with regard to the recommended safety distance.

Original abstract

Objectives: This prospective study was intended to evaluate the overall deviation in a clinical treatment setting to provide for quantification of the potential impairment of treatment safety and reliability with computer-assisted, template-guided transgingival implantation.

Materials and methods: The patient population enrolled (male/female=10/8) presented with partially dentate and edentulous maxillae and mandibles. Overall, 86 implants were placed by two experienced dental surgeons strictly following the NobelGuide protocol for template-guided implantation. All patients had a postoperative computed tomography (CT) with identical settings to the preoperative examination. Using the triple scan technique, pre- and postoperative CT data were merged in the Procera planning software, a newly developed procedure - initially presented in 2007 allowing measurement of the deviations at implant shoulder and apex.

Results: The deviations measured were an average of 0.43 mm (buccolingual), 0.46 mm (mesiodistal) and 0.53 mm (depth) at the level of the implant shoulder and slightly higher at the implant apex with an average of 0.7 mm (buccolingual), 0.63 mm (mesiodistal) and 0.52 mm (depth). The maximum deviation of 2.02 mm was encountered in the corono-apical direction. Significantly lower deviations were seen for implants in the anterior region vs. the posterior tooth region ($p < 0.01$, 0.31 vs. 0.5 mm), and deviations were also significantly lower in the mandible than in the maxilla ($p=0.04$, 0.36 vs. 0.45 mm) in the mesiodistal direction. Moreover, a significant correlation between deviation and mucosal thickness was seen and a learning effect was found over the time period of performance of the surgical procedures.

Conclusions: Template-guided implantation will ensure reliable transfer of preoperative computer-assisted planning into surgical practice. With regard to the required verification of treatment reliability of an implantation system with flapless access, all maximum deviations measured in this clinical study were within the safety margins recommended by the planning software.

Five-year follow-up of immediate fixed restorations of maxillary implants inserted in both fresh extraction and healed sites using the NobelGuide® system

Base portion of the radiographic guide

Tooth setup portion of the radiographic guide

The two assembled portions of the radiographic guide

2.5-years follow-up, upper arch

Periapical radiographs at 5 years

Original abstract

Background: Transition from a hopeless dentition to an implant prosthesis, without wearing a removable denture, requires adaptation with guided surgery in postextraction cases.

Purpose: The study aims to evaluate mid-term follow-up of patients with compromised dentition treated with immediate fixed restorations on maxillary implants inserted in fresh extraction and healed sites by using NobelGuide (Nobel Biocare AB, Gothenburg, Sweden) in combination with a specially designed radiographic stent.

Materials and methods: Twenty-seven patients (females 20, males 7) aged 34 to 71 years (mean 55.8) were treated with flapless surgery. Immediate full-arch (n = 19) or partial (n = 10) restorations were delivered. Patients were followed both clinically (mean 61.3 months, 48–77) and radiologically for up to 5 years (mean 46.5 months, 12–61). Cumulative survival rate (CSR) was assessed. Marginal bone remodeling was evaluated at implant insertion, after 2 and 4/5 years. Soft tissue parameters as well as biological and mechanical complications were also recorded.

Results: One hundred sixty implants were assessed. Four implants in two patients failed and were removed (overall CSR 97.33%), and two were replaced. All final prostheses were stable and in good function throughout the study. Bone loss from insertion to 2 years, for implants placed in both extraction and healed sites, was 0.85 mm (SD 1.28, n = 130); from insertion to last radiological control (4-5 years), 1.39 mm (SD 1.88, n = 127); and between 2 years and last control, 0.64 mm (SD 1.66, n = 111). No bone loss difference was found between extraction and healed sites at any time (p > .05). At the last visit, most implants showed normal mucosa. No other complications occurred.

Conclusions: This 5-year retrospective study demonstrated a good outcome with regard to implant survival, marginal bone changes and soft tissue conditions.

Technique to obtain a predictable esthetic result through appropriate placement of the prosthesis/soft tissue junction in the edentulous patient

Demurashvili G, Davarpanah K, Szmukler-Moncler S, Davarpanah M, Raux D, Capelle-Ouadah N, Rajzbaum P
Clin Implant Dent Relat Res. 2013 [epub ahead of print]

Simultaneous radiological reading of the bone and soft tissue landmarks. A, Three-dimensional reconstruction without recording the silicone guide. B, Two-dimensional transverse plan showing the guide and the radiopaque landmarks. C, Smile guide with the radiopaque markers. D, Three-dimensional reconstruction with the silicone guide (blue) and the radiopaque landmarks. E, Transverse sections with the simultaneously recorded bone and smile-line landmarks. The silicone guide and the smile line have been underlined (blue line). A 5 mm line has been measured from the smile line; it corresponds to the most coronal position of the implant neck. Apical to this line, the residual bone height was 13.6 mm, enough to host a 13 mm long implant as simulated with its multiunit abutment. In the present case, the implant has been simulated with its neck beyond the 5 mm line to account for the larger gum uncover that might occur during the dynamic smile.

Clinical preoperative situation. A, Nonfunctional and nonaesthetic teeth-supported overdenture. B, Situation after removal of the overdenture. Note the three ball attachments connected to the dental roots.

Follow-up at 3 months. A, Smile of the patient. B, Close-up of the smile. C, Clinical situation of the artificial pink and white. The transition line between the natural and artificial gingiva is beyond the smile line of the patient.

Original abstract

Background: Treating the edentulous patient with a gingival smile requires securing the prosthesis/soft tissue junction (PSTJ) under the upper lip.

Purpose: To present a simple method that helps achieve a predictable esthetic result when alveoplasty of the anterior maxilla is needed to place implants apical to the presurgical position of the alveolar ridge.

Materials and methods: The maximum smile line of the patient is recorded and carved on a thin silicone bite impression as a soft tissue landmark. During the three-dimensional radiographic examination, the patient wears the silicone guide loaded with radiopaque markers. The NobelClinician® software is then used to bring the hard and soft tissue landmarks together in a single reading. Using the software, a line is drawn 5 mm apical to the smile line; it dictates the position of the crestal ridge to be reached following the alveoplasty. Subsequently, the simulated implant position and the simulated residual bone height following alveoplasty can be simultaneously evaluated on each transverse section.

Results: An alveoplasty of the anterior maxilla was performed as simulated on the software, and implants were placed accordingly. The PSTJ was always under the upper lip, even during maximum smile events. The esthetic result was, therefore, fully satisfactory.

Conclusion: This simple method permits the placement of the PSTJ under the upper lip with a predictable outcome; it ensures a reliable esthetic result for the edentulous patient with a gingival smile.

Minimally invasive treatment of the atrophic posterior maxilla: a proof-of-concept prospective study with a follow-up of between 36 and 54 months

Pozzi A, Sannino G, Barlattani A
J Prosthet Dent. 2012;108:286-297

A, Implant angulation used to obtain an esthetic outcome with respect to parallelism with sinus walls.
B, Emergence profile of prosthetic guided implant position.

A, Soft tissue contours around axial and tilted implants.
B, Shaded zirconia framework was customized according to definitive prosthetic design to support veneer material.
C, Definitive zirconia ceramic framework prosthesis was placed 5 months after surgery.

A, Intra-oral radiograph immediately after definitive prosthesis placement.
B, Intra-oral radiograph at 36 months. Marginal bone resorption for axial and tilted implants was similar when axial and tilted implants were splinted together.

Original abstract

Statement of problem: In the posterior maxilla, tooth loss is usually associated with alveolar bone resorption and sinus pneumatization, limiting the placement of implants without grafting procedures.

Purpose: The purpose of this study was to evaluate minimally invasive treatment of the atrophic posterior maxilla with axial and tilted implants and immediate loading. The research hypothesis was that the combination of a guided, minimally invasive approach and the biomimetic features of computer-aided design and computer-aided manufacturing (CAD/CAM) abutments would be an effective alternative to maxillary sinus floor augmentation procedures with reduced bone resorption around implants.

Materials and methods: Twenty-seven consecutive participants (female=12, male=15) (mean age 54.18 years) with severe atrophy of the posterior maxilla were treated by using guided surgery with immediately loaded axial (39) and tilted (42) implants supporting CAD/CAM zirconia (39) and titanium (42) abutments (81 total) and partial fixed prostheses. Each participant underwent a computed tomography scan, after which 2 or 3 implants were positioned with a flapless or miniflap approach. The drilling protocol was adapted to the bone density of each implant site to obtain an insertion torque ranging between 40 and 50 Ncm. CAD/CAM customized abutments composed of zirconia or titanium were fixed to the implants with prosthetic screws tightened with a torque of 35 Ncm. An acrylic resin interim restoration reinforced with metal was placed immediately. 5 to 6 months after initial loading, a zirconia framework was manufactured, and a definitive prosthesis was placed. Clinical and radiological controls were performed at baseline and after 1 and 3 years to assess implant and prosthesis survival and success rate and compare marginal bone remodeling of axial and tilted implants. Inferential statistics for radiological data were acquired by using the Mann-Whitney U-test. All statistical comparisons were conducted at the .05 significance level.

Results: The mean follow-up period was 43.3 months (ranging from 36 months to 54 months). The cumulative implant survival rate was 96.3% at 3 years. All prosthetic restorations were stable and in good function, resulting in a cumulative prosthetic survival rate of 100%. Three restorations had chipping of the veneer material; thereafter, the cumulative prosthetic success rate was 91.9%.

Conclusions: Treatment of the posterior partially edentulous atrophic maxilla with guided surgery and immediate loading of tilted and straight implants supporting short-span partial fixed dental prostheses is effective.

Clinical implications: The 3-year results of this clinical study demonstrate that the combination of a guided, minimally invasive approach, tilted implants, and the biological features of CAD/CAM abutments is an effective and biologically beneficial alternative to augmentation of the maxillary sinus floor.

The NobelGuide® All-on-4® treatment concept for rehabilitation of edentulous jaws: a prospective report on medium- and long-term outcomes

Lopes A, Maló P, de Araújo Nobre M, Sanchez-Fernández E
Clin Implant Dent Relat Res. 2014 [epub ahead of print]

Three-dimensional computer planning.

Provisional all-acrylic fixed prosthesis in the articulator before surgery.

Anterior implant placement.

Mandibular intra-oral postoperative occlusal view with all-acrylic prosthesis.

Periapical maxilla radiograph at 5 years' follow-up.

Periapical mandibula radiograph at 5 years' follow-up.

Original abstract

Background: There is a need for long-term studies on complete edentulous flapless rehabilitations.

Purpose: This study aimed to evaluate the long-term outcomes of the rehabilitation of completely edentulous jaws for immediate function with the All-on-4® treatment concept using a computer-guided surgical protocol (NobelGuide®, Nobel Biocare, Goteborg, Sweden).

Materials and methods: This prospective clinical study included 23 totally edentulous patients rehabilitated between February 2005 and May 2006 with 92 implants with the All-on-4 treatment concept using NobelGuide. Outcome measures were implant survival, marginal bone loss at 1, 3, and 5 years, and the incidence of mechanical and biological complications. Survival was calculated using life-table analysis.

Results: Two dropouts occurred. The cumulative implant survival rate was 96.6% at 5 years of follow-up. Prosthetic survival was 100%. The average marginal bone loss was 1.7 mm (standard deviation 1.4 mm) at 1 year, 1.7 mm (standard deviation 0.9 mm) at 3 years, and 1.9 mm (standard deviation 1.1 mm) at 5 years. Seven patients experienced fracture of the definitive prosthesis (6 patients were heavy bruxers), and abutment screw loosening occurred in 2 patients. Two implants in 2 patients showed peri-implant pathology.

Conclusions: Within the limitations of this study, it is possible to conclude that this treatment modality for completely edentulous jaws is safe and predictable with good long-term outcomes.

Overview of studies –
NobelClinician® and NobelGuide®

The following overview lists clinical studies on NobelClinician and NobelGuide according to follow-up time.

Only peer-reviewed publications are listed. Meeting abstracts, reviews, and animal and *in vitro* tests are excluded.
For more information on these studies visit PubMed at pubmed.gov

Reference	Mean follow-up time	Study type	Indication / study focus	Treatment concept	Number of patients	Number of implants	CSR implants %*
Follow-up time > 5 years							
Orentlicher G, Horowitz A, Goldsmith D, Delgado-Ruiz R, Abboud M. (2014). Compend Contin Educ Dent. 35: 590-598, 600	7 years	Retrospective Monocenter Comparative	Maxilla and mandible Anterior and posterior Cement- and screw-retained	Healed and extraction sites 1- and 2-stage surgery	NR	674	96.7
Balshi T, Wolfinger G, Slauch R, Balshi S (2013). Int J Oral Maxillofac Implants 28: 184-189.	7 years	Retrospective Monocenter Comparative	Edentulous maxilla	Healed and extraction sites 1- and 2-stage surgery	NR	136	93.4
Polizzi G, Cantoni T (2015). Clin Implant Dent Relat Res 17: 221-233.	5.1 years	Retrospective Monocenter Comparative	Maxilla Screw-retained	Healed and extraction sites 1-stage flapless surgery Immediate loading	27	160	97.3
Lopes A, Malo P, de Araujo Nobre M, Sanchez-Fernandez E (epub ahead 2014). Clin Implant Dent Relat Res	5 years	Prospective Monocenter Single arm	Edentulous maxilla and mandible Screw-retained	1-stage flapless surgery Immediate loading All-on-4	23	92	96.6
Follow-up time > 1 to < 5 years							
Agliardi E, Tete S, Romeo D, Malchiodi L, Gherlone E (2014). J Craniofac Surg 25: 851-855.§	4.2 years	Prospective Monocenter Single arm	Partially edentulous maxilla Posterior	Healed and extraction sites 1-stage surgery Immediate loading	10	20	100
Schnitman PA, Hayashi C, Han RK (2014). J Oral Implantol 40: 670-678.	4.2 years	Retrospective Monocenter Single arm	Maxilla and mandible Anterior and posterior Cement- and screw-retained	1- and 2-stage surgery	27	80	100
Pozzi A, Tallarico M, Barlattani A (epub ahead 2013). Journal of Oral Implantology.	4.1 years	Prospective Monocenter Single arm	Edentulous maxilla and mandible Cement- and screw-retained	2-stage surgery Immediate loading	16	132	100
Pozzi A, Moy P (2014). Clin Implant Dent Relat Res 16: 582-593.	3.7 years	Prospective Multicenter Single arm	Maxilla Posterior Screw-retained	1-stage flapless surgery	66	136	98.5
Komiyama A, Klinge B, Hultin M (2008). Clin Oral Implants Res 19: 677-685.	3.7 years	Prospective Monocenter Single arm	Edentulous maxilla and mandible Screw-retained	1-stage flapless surgery Immediate loading	29	176	89.2
Pozzi A, Sannino G, Barlattani A (2012). J Prosthet Dent 108: 286-297.	3.6 years	Prospective Monocenter Single arm	Partially edentulous maxilla Posterior Cement-retained	1-stage surgery Immediate loading	27	81	96.3
Pozzi A, Holst S, Fabbri G, Tallarico M (2015). Clin Implant Dent Relat Res 17: e86-e96.	3.5 years	Retrospective Monocenter Comparative	Edentulous maxilla and mandible Screw-retained	Healed and extraction sites 1-stage surgery	22	170	100
Browaeys H, Dierens M, Ruyffelaert C, Matthijs C, De Bruyn H, Vandeweghe S. (epub ahead 2014) Clin Implant Dent Relat Res.	3 years	Prospective Monocenter Single arm	Edentulous maxilla and mandible Screw-retained	Healed sites 1-stage flapless surgery Immediate loading All-on-4	20	80	100

* If the CSR is not reported separately in the study, percentage of surviving implants was calculated.
§ Diagnostics and treatment planning with NobelClinician combined with freehand surgery.
NR: not reported

Reference	Mean follow-up time	Study type	Indication / study focus	Treatment concept	Number of patients	Number of implants	CSR implants %*
Marra R, Acocella A, Rispoli A, Sacco R, Ganz S, Blasi A (2013). Implant Dent 22: 444-452	3 years	Prospective Multicenter Single arm	Edentulous maxilla and mandible Screw-retained	1-stage flapless surgery Immediate loading	30	312	97.9
Lal K, Eisig S, Fine J, Papaspyridakos P (2013). Int J of Periodontics Restorative Dent 33: 661-667.	3 years	Retrospective Monocenter Single arm	Edentulous maxilla and mandible Cement- and screw-retained	1- and 2-stage flapless surgery	36	273	83.5
Papaspyridakos P, Lal K (2013). Clin Oral Implants Res 24 :659-665.	3 years	Retrospective Monocenter Single arm	Edentulous maxilla and mandible Screw-retained	2-stage flapless surgery	14	103	100
Nocini P Castellani R, Zanotti G, Bertossi D, Luciano U, De Santis D (2013). J Craniofac Surg 24: e551-558.	2.7 years	Retrospective Monocenter Single arm	Edentulous maxilla and mandible	Healed sites 1-stage flapless surgery Immediate loading	65	342	96.5
Gillot L, Noharet R, Cannas B (2010). Clin Implant Dent Relat Res 12 (Suppl 1): e104-113	2.6 years	Retrospective Multicenter Single arm	Edentulous maxilla Screw-retained	Healed and extraction sites 1-stage flapless surgery Immediate loading	33	211	98.1
Meloni SM, De Riu G, Pisano M, Lolli F, Deledda A, Campus G, Tullio A (2013). Int J Dent 2013: 683423.	2.5 years	Prospective Monocenter Single arm	Edentulous maxilla and mandible Screw-retained	Healed and extraction sites 1-stage surgery	20	120	97.7
Yong LT, Moy PK (2008) Clin Implant Dent Relat Res 10: 123-127.	2.2 years	Retrospective Monocenter Single arm	Maxilla and mandible Anterior and posterior Screw-retained	1-stage flapless surgery Immediate loading	13	78	91
Sanna A, Molly L, van Steenberghe D (2007). J Prosthet Dent 97: 331-339.	2.2 years	Retrospective Monocenter Single arm	Edentulous maxilla and mandible Screw-retained	Healed sites 1-stage flapless surgery Immediate loading	26	183	95
Meloni SM, De Riu G, Pisano M, Dell'aversana Orabona G, Piombino P, Salzano G, Quarato D, Riccardi E, Belli E, Ungari C (2013). Eur Rev Med Pharmacol Sci 17: 2968-2973.	2 years	Prospective Monocenter Single arm	Edentulous maxilla and mandible Screw-retained	Healed and extraction sites 1-stage flapless surgery Immediate loading	12	72	100
Rao W, Benzi R (2007). J Prosthet Dent 97 (6 Suppl): S3-S14.	2 years	Prospective Multicenter Single arm	Posterior mandible Single tooth Cement-retained	1-stage flapless surgery Immediate loading	46	51	100
Balshi SF, Wolfinger GJ, Balshi TJ (2008). Implant Dent 17: 128-135.	1.7 years	Monocenter Single arm	Edentulous maxilla and mandible Screw-retained	Immediate loading	23	168	97.6
Komiyama A, Hultin M, Nasstrom K, Benchimol D, Klinge B (2012). Clin Implant Dent Relat Res 14: 157-169.	1.6 years	Prospective Monocenter Single arm	Edentulous maxilla and mandible	1-stage flapless surgery Immediate loading	30	191	98.4
Meloni SM, De Riu G, Pisano M, Cattina G, Tullio A (2010). Eur J Oral Implantol 3: 245-251	1.5 years	Retrospective Monocenter Single arm	Edentulous maxilla Screw-retained	Healed sites 1-stage flapless surgery Immediate loading	15	90	97.8
Follow-up time 1 year							
Yamada J, Kori H, Tsukiyama Y, Matsushita Y, Kamo M, Koyano K (2015). Int J Oral Maxillofac Implants 30: 184-193.	1 year	Prospective Monocenter Single arm	Edentulous maxilla Screw-retained	Healed sites 1-stage flapless surgery Immediate loading	50	290	98.6
Pozzi A, Tallarico M, Marchetti M, Scarfo B, Esposito M (2014). Eur J Oral Implantol 7: 229-242.	1 year	Prospective Multicenter Randomized controlled	Partially and fully edentulous maxilla and mandible Guided vs. freehand	Healed and extraction sites 1-stage flapless surgery Immediate loading	25	103	100

Reference	Mean follow-up time	Study type	Indication / study focus	Treatment concept	Number of patients	Number of implants	CSR implants %*
Vasak C, Kohal RJ, Lettner S, Rohner D, Zechner W (2014). Clin Oral Implants Res 25: 116–123.	1 year	Prospective Multicenter Single arm	Maxilla and mandible Anterior and posterior Cement- and screw-retained	Healed and extraction sites 1- and 2-stage flapless surgery	30	163	98.8
Landazuri-Del Barrio RA, Cosyn J, De Paula WN, De Bruyn H, Marcantonio E, Jr (2013). Clin Oral Implants Res 24: 428-433.	1 year	Prospective Monocenter Single arm	Edentulous mandible Screw-retained	1-stage flapless surgery Immediate loading All-on-4	16	64	90.6
Meloni SM, De Riu G, Pisano M, Tullio A (2013). J Maxillofac Oral Surg 12: 321-325.	1 year	Prospective Monocenter Single arm	Edentulous maxilla and mandible Screw-retained	Healed and extraction sites 1-stage flapless surgery Immediate loading	10	60	100
Malo P, Rigolizzo M, Nobre M, Lopes A, Agliardi E (2013). Quintessence Int 44: 149-157.	1 year	Retrospective Monocenter Comparative	Edentulous mandible	1-stage flapless surgery Immediate loading All-on-4	39	156	97.3
Abboud M, Wahl G, Guirado J, Orentlicher G (2012). Int J Oral Maxillofac Implants 27: 634-643.	1 year	Prospective Comparative	Maxilla and mandible Anterior and posterior Cement-retained	Healed sites 1-stage flapless surgery	6	41	97.6
Meloni SM, De Riu G, Pisano M, Massarelli O, Tullio A (2012). Br J Oral Maxillofac Surg 50: 726-731.	1 year	Prospective Monocenter Single arm	Maxilla and mandible Anterior and posterior Screw-retained	1- and 2-stage flapless surgery	10	56	94.6
Puig CP (2010). Eur J Oral Implantol 3: 155-163.	1 year	Retrospective Monocenter Single arm	Edentulous maxilla and mandible	Healed sites 1-stage surgery Immediate loading	30	195	98
Johansson B, Friberg B, Nilson H (2009). Clin Implant Dent Relat Res 11: 194-200.	1 year	Prospective Multicenter Single arm	Edentulous maxilla Screw-retained	Healed sites 1-stage flapless surgery Immediate loading	52	312	99.4
van Steenberghe D, Glauser R, Blomback U, Andersson M, Schutyser F, Pettersson A, Wendelhag I (2005). Clin Implant Dent Relat Res 7 Suppl 1: S111-1120.	1 year	Prospective Multicenter Single arm	Edentulous maxilla Screw-retained	1-stage flapless surgery Immediate loading	27	184	100
Follow-up time < 1 year							
Merli M, Bernardelli F, Esposito M (2008). Eur J Oral Implantol 1: 61-69.	0.7 years	Prospective Monocenter Single arm	Edentulous maxilla Cement- and screw-retained	Healed sites 1-stage surgery	13	89	94.4
Katsoulis J, Avrampou M, Spycher C, Stipic M, Enkling N, Mericske-Stern R (2012). Clin Implant Dent Relat Res 14: 915-923.	0.3 years	Prospective Monocenter Comparative	Edentulous maxilla	Healed sites 1- and 2-stage flapless surgery Delayed loading	17	85	100
Penarrocha M, Vina J, Maestre L, Penarrocha D, Balaguer J (2012). Med Oral Patol Oral Cir Bucal 17: e775-780.	0.3 years	Retrospective Monocenter Comparative	Screw-retained	1-stage surgery Immediate loading	12	19	94.8

* If the CSR is not reported in the study, percentage of surviving implants was calculated.

References

1   Dreiseidler T, Mischkowski RA, Neugebauer J, Ritter L, Zoller JE. Comparison of cone-beam imaging with orthopantomography and computerized tomography for assessment in presurgical implant dentistry. Int J Oral Maxillofac Implants 2009;24(2):216-25.

2   Vandenberghe B, Luchsinger S, Hostens J, Dhoore E, Jacobs R. The influence of exposure parameters on jawbone model accuracy using cone beam CT and multislice CT. Dentomaxillofac Radiol 2012;41(6):466-74.

3   Marchack CB, Charles A, Matosian AJ. A subtractive radiographic template for computer-guided surgery. J Prosthet Dent 2014;112(4):1006-8.

4   Pozzi A, Sannino G, Barlattani A. Minimally invasive treatment of the atrophic posterior maxilla: a proof-of-concept prospective study with a follow-up of between 36 and 54 months. J Prosthet Dent 2012;108(5):286-97.

5   Pozzi A, Moy PK. Minimally invasive transcrestal guided sinus lift (TGSL): a clinical prospective proof-of-concept cohort study up to 52 months. Clin Implant Dent Relat Res 2014;16(4):582-93.

6   Lozada JL, Garbacea A, Goodacre CJ, Kattadiyil MT. Use of a digitally planned and fabricated mandibular complete denture for easy conversion to an immediately loaded provisional fixed complete denture. Part 1. Planning and surgical phase. Int J Prosthodont 2014;27(5):417-21.

7   Polizzi G, Cantoni T. Five-Year Follow-Up of Immediate Fixed Restorations of Maxillary Implants Inserted in Both Fresh Extraction and Healed Sites Using the NobelGuide™ System. Clinical Implant Dentistry and Related Research 2015;17(2):221-33.

8   Tyndall DA, Price JB, Tetradis S, Ganz SD, Hildebolt C, Scarfe WC. Position statement of the American Academy of Oral and Maxillofacial Radiology on selection criteria for the use of radiology in dental implantology with emphasis on cone beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol 2012;113(6):817-26.

9   Benavides E, Rios HF, Ganz SD, An CH, Resnik R, Reardon GT, et al. Use of cone beam computed tomography in implant dentistry: the International Congress of Oral Implantologists consensus report. Implant Dent 2012;21(2): 78-86.

10   Chan HL, Misch K, Wang HL. Dental imaging in implant treatment planning. Implant Dent 2010;19(4):288-98.

11   Sukovic P. Cone beam computed tomography in craniofacial imaging. Orthod Craniofac Res 2003;6 Suppl 1:31-6; discussion 179-82.

12   Tsiklakis K, Donta C, Gavala S, Karayianni K, Kamenopoulou V, Hourdakis CJ. Dose reduction in maxillofacial imaging using low dose Cone Beam CT. Eur J Radiol 2005;56(3):413-7.

13   Miracle AC, Mukherji SK. Conebeam CT of the head and neck, part 1: physical principles. AJNR Am J Neuroradiol 2009;30(6):1088-95.

14   Mozzo P, Procacci C, Tacconi A, Martini PT, Andreis IA. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. Eur Radiol 1998;8(9):1558-64.

15   Arai Y, Tammisalo E, Iwai K, Hashimoto K, Shinoda K. Development of a compact computed tomographic apparatus for dental use. Dentomaxillofac Radiol 1999;28(4):245-8.

16   Kau CH, Bozic M, English J, Lee R, Bussa H, Ellis RK. Cone-beam computed tomography of the maxillofacial region--an update. Int J Med Robot 2009;5(4):366-80.

17   Dawood A, Patel S, Brown J. Cone beam CT in dental practice. Br Dent J 2009;207(1):23-8.

18   Suetens P. Fundamentals of medical imaging. 2nd edition ed: Cambridge University Press; 2009.

19   Pozzi A, Tallarico M, Marchetti M, Scarfo B, Esposito M. Computer-guided versus free-hand placement of immediately loaded dental implants: 1-year post-loading results of a multicentre randomised controlled trial. Eur J Oral Implantol 2014;7(3):229-42.

20   van Steenberghe D, Glauser R, Blomback U, Andersson M, Schutyser F, Pettersson A, et al. A computed tomographic scan-derived customized surgical template and fixed prosthesis for flapless surgery and immediate loading of implants in fully edentulous maxillae: a prospective multicenter study. Clin Implant Dent Relat Res 2005;7 Suppl 1:S111-20.

21   Abad-Gallegos M, Gomez-Santos L, Sanchez-Garces MA, Pinera-Penalva M, Freixes-Gil J, Castro-Garcia A, et al. Complications of guided surgery and immediate loading in oral implantology: a report of 12 cases. Med Oral Patol Oral Cir Bucal 2011;16(2):e220-4.

22   Busenlechner D, Mailath-Pokorny G, Fürhauser R, Haas R, Watzek G, Pommer B. Virtual treatment planning and flapless single-tooth implants in the esthetic zone following socket augmentation surgery: proof of concept. In Periodontology EFo (ed) 8th Congress of the European Federation of Periodontology (EUROPERIO),[#P1140]. London, UK: Journal of Clinical Periodontology 2015;413.

23   Mello LA, Garcia RR, Leles JL, Leles CR, Silva MA. Impact of cone-beam computed tomography on implant planning and on prediction of implant size. Braz Oral Res 2014;28(1):46-53.

24   White SC, Pharoah M. Oral Radiology: Principles and interpretation. 7th edition ed: Elsevier; 2013.

25   Scarfe WC, Farman AG. What is cone-beam CT and how does it work? Dent Clin North Am 2008;52(4):707-30, v.

26   Hoseini Zarch SH, Bagherpour A, Javadian Langaroodi A, Ahmadian Yazdi A, Safaei A. Evaluation of the accuracy of panoramic radiography in linear measurements of the jaws. Iran J Radiol 2011;8(2):97-102.

27   Bou Serhal C, Jacobs R, Gijbels F, Bosmans H, Hermans R, Quirynen M, et al. Absorbed doses from spiral CT and conventional spiral tomography: a phantom vs. cadaver study. Clin Oral Implants Res 2001;12(5):473-8.

28   Gupta J, Ali SP. Cone beam computed tomography in oral implants. Natl J Maxillofac Surg 2013;4(1):2-6.

29   Harris D, Horner K, Grondahl K, Jacobs R, Helmrot E, Benic GI, et al. E.A.O. guidelines for the use of diagnostic imaging in implant dentistry 2011. A consensus workshop organized by the European Association for Osseointegration at the Medical University of Warsaw. Clin Oral Implants Res 2012;23(11):1243-53.

30   Loubele M, Bogaerts R, Van Dijck E, Pauwels R, Vanheusden S, Suetens P, et al. Comparison between effective radiation dose of CBCT and MSCT scanners for dentomaxillofacial applications. Eur J Radiol 2009;71(3):461-8.

31   Okano T, Harata Y, Sugihara Y, Sakaino R, Tsuchida R, Iwai K, et al. Absorbed and effective doses from cone beam volumetric imaging for implant planning. Dentomaxillofac Radiol 2009;38(2):79-85.

32 Suomalainen A, Kiljunen T, Kaser Y, Peltola J, Kortesniemi M. Dosimetry and image quality of four dental cone beam computed tomography scanners compared with multislice computed tomography scanners. Dentomaxillofac Radiol 2009;38(6):367-78.

33 Ludlow JB, Ivanovic M. Comparative dosimetry of dental CBCT devices and 64-slice CT for oral and maxillofacial radiology. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;106(1):106-14.

34 Loubele M, Maes F, Schutyser F, Marchal G, Jacobs R, Suetens P. Assessment of bone segmentation quality of cone-beam CT versus multislice spiral CT: a pilot study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;102(2):225-34.

35 Ngan DC, Kharbanda OP, Geenty JP, Darendeliler MA. Comparison of radiation levels from computed tomography and conventional dental radiographs. Aust Orthod J 2003;19(2):67-75.

36 Ludlow JB, Davies-Ludlow LE, White SC. Patient risk related to common dental radiographic examinations: the impact of 2007 International Commission on Radiological Protection recommendations regarding dose calculation. J Am Dent Assoc 2008;139(9):1237-43.

37 Gijbels F, Jacobs R, Bogaerts R, Debaveye D, Verlinden S, Sanderink G. Dosimetry of digital panoramic imaging. Part I: Patient exposure. Dentomaxillofac Radiol 2005;34(3):145-9.

38 Vandenberghe B, Jacobs R, Bosmans H. Modern dental imaging: a review of the current technology and clinical applications in dental practice. Eur Radiol 2010;20(11):2637-55.

39 Ludlow JB, Davies-Ludlow LE, Brooks SL. Dosimetry of two extraoral direct digital imaging devices: NewTom cone beam CT and Orthophos Plus DS panoramic unit. Dentomaxillofac Radiol 2003;32(4):229-34.

40 Ludlow JB, Davies-Ludlow LE, Brooks SL, Howerton WB. Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. Dentomaxillofac Radiol 2006;35(4):219-26.

41 Qu XM, Li G, Ludlow JB, Zhang ZY, Ma XC. Effective radiation dose of ProMax 3D cone-beam computerized tomography scanner with different dental protocols. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;110(6):770-6.

42 Nair MK, Nair UP. Digital and advanced imaging in endodontics: a review. J Endod 2007;33(1):1-6.

43 Quintero JC, Trosien A, Hatcher D, Kapila S. Craniofacial imaging in orthodontics: historical perspective, current status, and future developments. Angle Orthod 1999;69(6):491-506.

44 Scarfe WC. Imaging of maxillofacial trauma: evolutions and emerging revolutions. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;100(2 Suppl):S75-96.

45 Cohenca N, Simon JH, Roges R, Morag Y, Malfaz JM. Clinical indications for digital imaging in dento-alveolar trauma. Part 1: traumatic injuries. Dent Traumatol 2007;23(2):95-104.

46 BouSerhal C, Jacobs R, Quirynen M, van Steenberghe D. Imaging technique selection for the preoperative planning of oral implants: a review of the literature. Clin Implant Dent Relat Res 2002;4(3):156-72.

47 Guerrero ME, Jacobs R, Loubele M, Schutyser F, Suetens P, van Steenberghe D. State-of-the-art on cone beam CT imaging for preoperative planning of implant placement. Clin Oral Investig 2006;10(1):1-7.

48 Dula K, Bornstein MM, Buser D, Dagassan-Berndt D, Ettlin DA, Filippi A, et al. SADMFR guidelines for the use of Cone-Beam Computed Tomography/ Digital Volume Tomography. Swiss Dent J 2014;124(11):1169-83.

49 Farman AG. ALARA still applies. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;100(4):395-7.

50 Pauwels R, Stamatakis H, Manousaridis G, Walker A, Michielsen K, Bosmans H, et al. Development and applicability of a quality control phantom for dental cone-beam CT. J Appl Clin Med Phys 2011;12(4):3478.

51 Ludlow JB, Walker C. Assessment of phantom dosimetry and image quality of i-CAT FLX cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2013;144(6):802-17.

52 Flicek KT, Hara AK, Silva AC, Wu Q, Peter MB, Johnson CD. Reducing the radiation dose for CT colonography using adaptive statistical iterative reconstruction: A pilot study. AJR Am J Roentgenol 2010;195(1):126-31.

53 Sagara Y, Hara AK, Pavlicek W, Silva AC, Paden RG, Wu Q. Abdominal CT: comparison of low-dose CT with adaptive statistical iterative reconstruction and routine-dose CT with filtered back projection in 53 patients. AJR Am J Roentgenol 2010;195(3):713-9.

54 Silva AC, Lawder HJ, Hara A, Kujak J, Pavlicek W. Innovations in CT dose reduction strategy: application of the adaptive statistical iterative reconstruction algorithm. AJR Am J Roentgenol 2010;194(1):191-9.

55 Leipsic J, Labounty TM, Heilbron B, Min JK, Mancini GB, Lin FY, et al. Estimated radiation dose reduction using adaptive statistical iterative reconstruction in coronary CT angiography: the ERASIR study. AJR Am J Roentgenol 2010;195(3):655-60.

56 Hofmann E, Schmid M, Lell M, Hirschfelder U. Cone beam computed tomography and low-dose multislice computed tomography in orthodontics and dentistry: a comparative evaluation on image quality and radiation exposure. J Orofac Orthop 2014;75(5):384-98.

57 Hofmann E, Schmid M, Sedlmair M, Banckwitz R, Hirschfelder U, Lell M. Comparative study of image quality and radiation dose of cone beam and low-dose multislice computed tomography--an in-vitro investigation. Clin Oral Investig 2014;18(1):301-11.

58 von See C, Bormann KH, Schumann P, Goetz F, Gellrich NC, Rucker M. Forensic imaging of projectiles using cone-beam computed tomography. Forensic Sci Int 2009;190(1-3):38-41.

59 Valentin J. Managing patient dose in multi-detector computed tomography(MDCT). ICRP Publication 102. Ann ICRP 2007;37(1):1-79, iii.

60 Taguchi A, Asano A, Ohtsuka M, Nakamoto T, Suei Y, Tsuda M, et al. Observer performance in diagnosing osteoporosis by dental panoramic radiographs: results from the osteoporosis screening project in dentistry (OSPD). Bone 2008;43(1):209-13.

61 Mussig E, Wortche R, Lux CJ. Indications for digital volume tomography in orthodontics. J Orofac Orthop 2005;66(3):241-9.

62 Brooks SL. Guidelines for prescribing dental radiographs. In: White SC, Pharoah M, editors. Oral Radiology: Principles and interpretation. 6 ed: Elsevier; 2009. p. 244-55.

63 Communities OfOPotE. European guidelines on radiation protection in dental radiology – The safe use of radiographs in dental practice. In: Protection DH-NSaSUH-R, editor. Luxembourg: Office for Official Publications of the European Communities; 2004.

64 Lapp RM, Kyriakou Y, Kachelriess M, Wilharm S, Kalender WA. Interactively variable isotropic resolution in computed tomography. Phys Med Biol 2008;53(10):2693-713.

65 Januario AL, Barriviera M, Duarte WR. Soft tissue cone-beam computed tomography: a novel method for the measurement of gingival tissue and the dimensions of the dentogingival unit. J Esthet Restor Dent 2008;20(6):366-73; discussion 74.

66   Mah P, Reeves TE, McDavid WD. Deriving Hounsfield units using grey levels in cone beam computed tomography. Dentomaxillofac Radiol 2010;39(6):323-35.

67   Gonzalez-Garcia R, Monje F. The reliability of cone-beam computed tomography to assess bone density at dental implant recipient sites: a histomorphometric analysis by micro-CT. Clin Oral Implants Res 2013;24(8):871-9.

68   Chau AC, Fung K. Comparison of radiation dose for implant imaging using conventional spiral tomography, computed tomography, and cone-beam computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;107(4):559-65.

69   Pauwels R, Beinsberger J, Collaert B, Theodorakou C, Rogers J, Walker A, et al. Effective dose range for dental cone beam computed tomography scanners. Eur J Radiol 2012;81(2):267-71.

70   Liang X, Jacobs R, Hassan B, Li L, Pauwels R, Corpas L, et al. A comparative evaluation of Cone Beam Computed Tomography (CBCT) and Multi-Slice CT (MSCT) Part I. On subjective image quality. Eur J Radiol 2010;75(2):265-9.

71   Loubele M, Maes F, Jacobs R, van Steenberghe D, White SC, Suetens P. Comparative study of image quality for MSCT and CBCT scanners for dentomaxillofacial radiology applications. Radiat Prot Dosimetry 2008;129(1-3):222-6.

72   Lascala CA, Panella J, Marques MM. Analysis of the accuracy of linear measurements obtained by cone beam computed tomography (CBCT-NewTom). Dentomaxillofac Radiol 2004;33(5):291-4.

73   Lund H, Grondahl K, Grondahl HG. Accuracy and precision of linear measurements in cone beam computed tomography Accuitomo tomograms obtained with different reconstruction techniques. Dentomaxillofac Radiol 2009;38(6):379-86.

74   Moreira CR, Sales MA, Lopes PM, Cavalcanti MG. Assessment of linear and angular measurements on three-dimensional cone-beam computed tomographic images. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;108(3):430-6.

75   Wang Y, He S, Yu L, Li J, Chen S. Accuracy of volumetric measurement of teeth in vivo based on cone beam computer tomography. Orthod Craniofac Res 2011;14(4):206-12.

76   Watanabe H, Honda E, Kurabayashi T. Modulation transfer function evaluation of cone beam computed tomography for dental use with the oversampling method. Dentomaxillofac Radiol 2010;39(1):28-32.

77   Vasak C, Watzak G, Gahleitner A, Strbac G, Schemper M, Zechner W. Computed tomography-based evaluation of template (NobelGuide™)-guided implant positions: a prospective radiological study. Clin Oral Implants Res 2011;22(10):1157-63.

78   Van Assche N, van Steenberghe D, Quirynen M, Jacobs R. Accuracy assessment of computer-assisted flapless implant placement in partial edentulism. J Clin Periodontol 2010;37(4):398-403.

79   Verhamme LM, Meijer GJ, Boumans T, Schutyser F, Berge SJ, Maal TJ. A clinically relevant validation method for implant placement after virtual planning. Clin Oral Implants Res 2013;24(11):1265-72.

80   Imburgia M. Patient and team communication in the iPad era - a practical appraisal. Int J Esthet Dent 2014;9(1):26-39.

81   Imburgia M, Coachman C. Using digital devices to improve communications between clinicians and patients during implantprosthetic treatment: a clinical study [#519]. 23rd Annual Scientific Meeting of the European Association for Osseointegration. Rome, Italy: Wiley; 2014. p. 538.

82   van Steenberghe D, Naert I, Andersson M, Brajnovic I, Van Cleynenbreugel J, Suetens P. A custom template and definitive prosthesis allowing immediate implant loading in the maxilla: a clinical report. Int J Oral Maxillofac Implants 2002;17(5):663-70.

83   Van Assche N, van Steenberghe D, Guerrero ME, Hirsch E, Schutyser F, Quirynen M, et al. Accuracy of implant placement based on pre-surgical planning of three-dimensional cone-beam images: a pilot study. J Clin Periodontol 2007;34(9):816-21.

84   Scotti R, Pellegrino G, Marchetti C, Corinaldesi G, Ciocca L. Diagnostic value of NobelGuide to minimize the need for reconstructive surgery of jaws before implant placement: a review. Quintessence Int 2010;41(10):809-14.

85   Wouters V, Van Leemput P, Keustermans J, Mollemans W, Schutyser F. Accuracy of a surface scan based surgical template created with NobelClinician. Manuscript in preparation 2014.

86   Verhamme LM, Meijer GJ, Boumans T, de Haan AFJ, Bergé SJ, Maal TJJ. A Clinically Relevant Accuracy Study of Computer-Planned Implant Placement in the Edentulous Maxilla Using Mucosa-Supported Surgical Templates. Clin Implant Dent Relat Res 2015;17(2):343-52.

87   Furhauser R, Mailath-Pokorny G, Haas R, Busenlechner D, Watzek G, Pommer B. Esthetics of Flapless Single-Tooth Implants in the Anterior Maxilla Using Guided Surgery: Association of Three-Dimensional Accuracy and Pink Esthetic Score. Clin Implant Dent Relat Res epub ahead 2014.

88   Pettersson A, Komiyama A, Hultin M, Nasstrom K, Klinge B. Accuracy of virtually planned and template guided implant surgery on edentate patients. Clin Implant Dent Relat Res 2012;14(4):527-37.

89   Verstreken K, Van Cleynenbreugel J, Martens K, Marchal G, van Steenberghe D, Suetens P. An image-guided planning system for endosseous oral implants. IEEE Trans Med Imaging 1998;17(5):842-52.

90   Jacobs R, Adriansens A, Verstreken K, Suetens P, van Steenberghe D. Predictability of a three-dimensional planning system for oral implant surgery. Dentomaxillofac Radiol 1999;28(2):105-11.

91   Jacobs R, Adriansens A, Naert I, Quirynen M, Hermans R, Van Steenberghe D. Predictability of reformatted computed tomography for pre-operative planning of endosseous implants. Dentomaxillofac Radiol 1999;28(1):37-41.

92   Fortin T, Camby E, Alik M, Isidori M, Bouchet H. Panoramic images versus three-dimensional planning software for oral implant planning in atrophied posterior maxillary: a clinical radiological study. Clin Implant Dent Relat Res 2013;15(2):198-204.

93   Pertl L, Gashi-Cenkoglu B, Reichmann J, Jakse N, Pertl C. Preoperative assessment of the mandibular canal in implant surgery: comparison of rotational panoramic radiography (OPG), computed tomography (CT) and cone beam computed tomography (CBCT) for preoperative assessment in implant surgery. Eur J Oral Implantol 2013;6(1):73-80.

94   Jung RE, Schneider D, Ganeles J, Wismeijer D, Zwahlen M, Hammerle CH, et al. Computer technology applications in surgical implant dentistry: a systematic review. Int J Oral Maxillofac Implants 2009;24 Suppl:92-109.

95   Schneider D, Marquardt P, Zwahlen M, Jung RE. A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry. Clin Oral Implants Res 2009;20 Suppl 4:73-86.

96   Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. J Prosthet Dent 2003;90(2):121-32.

97 Hillerup S. Iatrogenic injury to the inferior alveolar nerve: etiology, signs and symptoms, and observations on recovery. Int J Oral Maxillofac Surg 2008;37(8):704-9.

98 Van Steenberghe D, Malevez C, Van Cleynenbreugel J, Bou Serhal C, Dhoore E, Schutyser F, et al. Accuracy of drilling guides for transfer from three-dimensional CT-based planning to placement of zygoma implants in human cadavers. Clin Oral Implants Res 2003;14(1):131-6.

99 Agliardi EL, Tete S, Romeo D, Malchiodi L, Gherlone E. Immediate function of partial fixed rehabilitation with axial and tilted implants having intrasinus insertion. J Craniofac Surg 2014;25(3):851-855.

100 Hultin M, Svensson KG, Trulsson M. Clinical advantages of computer-guided implant placement: a systematic review. Clin Oral Implants Res 2012;23 Suppl 6:124-35.

101 Meloni SM, Tallarico M, De Riu G, Pisano M, Deledda A, Lolli FM, Massarelli O, Tullio A. Guided implant surgery after free-flap reconstruction: Four-year results from a prospective clinical trial. J Craniomaxillofac Surg. epub ahead 2015.

102 Demurashvili G, Davarpanah K, Szmukler-Moncler S, Davarpanah M, Raux D, Capelle-Ouadah N, et al. Technique to Obtain a Predictable Aesthetic Result through Appropriate Placement of the Prosthesis/Soft Tissue Junction in the Edentulous Patient with a Gingival Smile. Clin Implant Dent Relat Res epub ahead 2013.

103 Puig CP. A retrospective study of edentulous patients rehabilitated according to the 'all-on-four' or the 'all-on-six' immediate function concept using flapless computer-guided implant surgery. Eur J Oral Implantol 2010;3(2):155-63.

104 Merli M, Bernardelli F, Esposito M. Computer-guided flapless placement of immediately loaded dental implants in the edentulous maxilla: a pilot prospective case series. Eur J Oral Implantol 2008;1(1):61-9.

105 Meloni SM, De Riu G, Pisano M, Cattina G, Tullio A. Implant treatment software planning and guided flapless surgery with immediate provisional prosthesis delivery in the fully edentulous maxilla. A retrospective analysis of 15 consecutively treated patients. Eur J Oral Implantol 2010;3(3):245-51.

106 Pozzi A, Holst S, Fabbri G, Tallarico M. Clinical Reliability of CAD/CAM Cross-Arch Zirconia Bridges on Immediately Loaded Implants Placed with Computer-Assisted/Template-Guided Surgery: A Retrospective Study with a Follow-Up between 3 and 5 Years. Clin Implant Dent Relat Res 2015;17(S1):e86-e96.

107 Tahmaseb A, Wismeijer D, Coucke W, Derksen W. Computer technology applications in surgical implant dentistry: a systematic review. Int J Oral Maxillofac Implants 2014;29 Suppl:25-42.

108 Nickenig HJ, Wichmann M, Hamel J, Schlegel KA, Eitner S. Evaluation of the difference in accuracy between implant placement by virtual planning data and surgical guide templates versus the conventional free-hand method - a combined in vivo - in vitro technique using cone-beam CT (Part II). J Craniomaxillofac Surg 2010;38(7):488-93.

109 Vasak C, Strbac GD, Huber CD, Lettner S, Gahleitner A, Zechner W. Evaluation of Three Different Validation Procedures regarding the Accuracy of Template-Guided Implant Placement: An In Vitro Study. Clin Implant Dent Relat Res 2015;17(1):142-9.

110 Komiyama A, Pettersson A, Hultin M, Nasstrom K, Klinge B. Virtually planned and template-guided implant surgery: an experimental model matching approach. Clin Oral Implants Res 2011;22(3):308-13.

111 Dreiseidler T, Neugebauer J, Ritter L, Lingohr T, Rothamel D, Mischkowski RA, Zöller JE. Accuracy of a newly developed integrated system for dental implant planning. Clin Oral Implants Res 2009;20(11):1191-9.

112 Pettersson A, Kero T, Gillot L, Cannas B, Faldt J, Soderberg R, et al. Accuracy of CAD/CAM-guided surgical template implant surgery on human cadavers: Part I. J Prosthet Dent 2010;103(6):334-42.

113 Di Giacomo GA, Cury PR, de Araujo NS, Sendyk WR, Sendyk CL. Clinical application of stereolithographic surgical guides for implant placement: preliminary results. J Periodontol 2005;76(4):503-7.

114 Sun Y, Luebbers H-T, Agbaje JO, Schepers S, Politis C, Van Slycke S, Vrielinck L. Accuracy of Dental Implant Placement Using CBCT-Derived Mucosa-Supported Stereolithographic Template. Clinical Implant Dentistry and Related Research epub ahead 2014.

115 Verhamme LM, Meijer GJ, Berge SJ, Soehardi RA, Xi T, de Haan AF, Schutyser F, Maal TJ. An Accuracy Study of Computer-Planned Implant Placement in the Augmented Maxilla Using Mucosa-Supported Surgical Templates. Clin Implant Dent Relat Res epub ahead 2014.

116 Sicilia A, Botticelli D, Working Group 3. Computer-guided implant therapy and soft- and hard-tissue aspects. The Third EAO Consensus Conference 2012. Clin Oral Implants Res. 2012;23 suppl 6:157-161.

117 Balshi TJ, Wolfinger GJ, Slauch RW, Balshi SF. A retrospective comparison of implants in the pterygomaxillary region: implant placement with two-stage, single-stage, and guided surgery protocols. Int J Oral Maxillofac Implants 2013;28(1):184-9.

118 Lopes A, Malo P, de Araujo Nobre M, Sanchez-Fernandez E. The NobelGuide® All-on-4® Treatment Concept for Rehabilitation of Edentulous Jaws: A Prospective Report on Medium- and Long-Term Outcomes. Clin Implant Dent Relat Res epub ahead 2014.

119 Pozzi A, Tallarico M, Barlattani A. Monolithic lithium disilicate full-contour crowns bonded on CAD/CAM zirconia complete-arch implant bridges with 3 to 5 years of follow-up. Journal of Oral Implantology epub ahead 2013.

120 Komiyama A, Klinge B, Hultin M. Treatment outcome of immediately loaded implants installed in edentulous jaws following computer-assisted virtual treatment planning and flapless surgery. Clin Oral Implants Res 2008;19(7):677-85.

121 Sanna AM, Molly L, van Steenberghe D. Immediately loaded CAD-CAM manufactured fixed complete dentures using flapless implant placement procedures: a cohort study of consecutive patients. J Prosthet Dent 2007;97(6):331-9.

122 Vasak C, Kohal RJ, Lettner S, Rohner D, Zechner W. Clinical and radiological evaluation of a template-guided (NobelGuide) treatment concept. Clin Oral Implants Res 2014;25(1):116-23.

123 Nocini PF, Castellani R, Zanotti G, Bertossi D, Luciano U, De Santis D. The use of computer-guided flapless dental implant surgery (NobelGuide) and immediate function to support a fixed full-archprosthesis infresh-frozen homologous patients with bone grafts. J Craniofac Surg 2013;24(6):e551-8.

124 Nkenke E, Eitner S, Radespiel-Troger M, Vairaktaris E, Neukam FW, Fenner M. Patient-centred outcomes comparing transmucosal implant placement with an open approach in the maxilla: a prospective, non-randomized pilot study. Clin Oral Implants Res 2007;18(2):197-203.

125 Bertossi D, Gerosa R, Schembri E, Zanotti G, Rossini N, Colletti G, Rossetto A, Chiarini L, Nocini PF. NobelGuide influence in the perception of postoperative pain. Minerva Stomatol epub ahead 2013.

126 Marra R, Acocella A, Rispoli A, Sacco R, Ganz SD, Blasi A. Full-mouth rehabilitation with immediate loading of implants inserted with computer-guided flap-less surgery: a 3-year multicenter clinical evaluation with oral health impact profile. Implant Dent 2013;22(5):444-52.

127 Joda T, Bragger U. Digital vs. conventional implant prosthetic workflows: a cost/time analysis. Clin Oral Implants Res epub ahead 2014.

128 Pozzi A, DE Vico G, Sannino G, Spinelli D, Schiavetti R, Ottria L, Barlattani A. Flapless Transcrestal Maxillary Sinus Floor Elevation: computer guided implant surgery combined with expanding-condensing osteotomes protocol. Oral Implantol (Rome) 2011;4:4-9.

129 Orentlicher G, Horowitz A, Goldsmith D, Delgado-Ruiz R, Abboud M. Cumulative survival rate of implants placed "fully guided" using CT-guided surgery: a 7-year retrospective study. Compend Contin Educ Dent. 2014;35(8):590-98, 600.

130 Schnitman PA, Hayashi C, Han RK. Why guided when freehand is easier, quicker, and less costly? J Oral Implantol. 2014;40(6):670-8.

131 Van Assche N, Vercruyssen M, Coucke W, Teughels W, Jacobs R, Quirynen M. Accuracy of computer-aided implant placement. Clin Oral Implants Res 2012;23 (supp6):112-23.

132 Meloni SM, De Riu G, Pisano M, Tullio A. Full arch restoration with computer-assisted implant surgery and immediate loading in edentulous ridges with dental fresh extraction sockets. One year results of 10 consecutively treated patients: guided implant surgery and extraction sockets. J Maxillofac Oral Surg 2013;12:321-5.

133 Meloni SM, De Riu G, Pisano M, Dell'aversana Orabona G, Piombino P, Salzano G, Quarato D, Riccardi E, Belli E, Ungari C. Computer-assisted implant surgery and immediate loading in edentulous ridges with dental fresh extraction sockets. Two years results of a prospective case series study. Eur Rev Med Pharmacol Sci 2013;17:2968-73.

134 Yamada J, Kori H, Tsukiyama Y, Matsushita Y, Kamo M, Koyano K. Immediate Loading of Complete-Arch Fixed Prostheses for Edentulous Maxillae After Flapless Guided Implant Placement: A 1-Year Prospective Clinical Study. Int J Oral Maxillofac Implants 2015;30:184-193.

135 Penarrocha M, Vina J, Maestre L D. Penarrocha and J. Balaguer. Guided implant surgery with modification of the technique involving the raising of a semicircular miniflap: a preliminary study. Med Oral Patol Oral Cir Bucal 2012;17:e775-80.

136 Verhamme LM, Meijer GJ, Berge SJ, Maal TJ. The use of first stage bone augmentation screws to stabilize the surgical template in the second stage. Int J Oral Maxillofac Surg epub ahead 2015.

137 Ochi M, Kanazawa M, Sato D et al. Factors affecting accuracy of implant placement with mucosa-supported stereolithographic surgical guides in edentulous mandibles. Comput Biol Med 2013;43:1653-60.

138 Wouters V, Mollemans W, Schutyser F. Calibrated segmentation of CBCT for digitization of dental prostheses. Int J Comput Assist Radiol Surg 2011;6(5):609–16.

139 Orentlicher G, Goldsmith D, Abboud M. Computer-guided planning and placement of dental implants. Atlas Oral Maxillofac Surg Clin North Am 2012;20:53-79.

140 Browaeys H, Dierens M, Ruyffelaert C, Matthijs C, De Bruyn H, Vandeweghe S. Ongoing Crestal Bone Loss around Implants Subjected to Computer-Guided Flapless Surgery and Immediate Loading Using the All-on-4® Concept. Clin Implant Dent Relat Res. epub ahead 2014.

141 Marra R, Acocella A, Rispoli A, Sacco R, Ganz SD, Blasi A. Full-mouth rehabilitation with immediate loading of implants inserted with computer-guided flap-less surgery: a 3-year multicenter clinical evaluation with oral health impact profile. Implant Dent. 2013;22(5):444-52.

142 Lal K, Eisig SB, Fine JB, Papaspyridakos P. Prosthetic outcomes and survival rates of implants placed with guided flapless surgery using stereolithographic templates: a retrospective study. Int J Periodontics Restorative Dent. 2013;33(5):661-7.

143 Papaspyridakos P, Lal K. Computer-assisted design/computer-assisted manufacturing zirconia implant fixed complete prostheses: clinical results and technical complications up to 4 years of function. Clin Oral Implants Res. 2013;24(6):659-65.

144 Gillot L, Noharet R, Cannas B. Guided surgery and presurgical prosthesis: preliminary results of 33 fully edentulous maxillae treated in accordance with the NobelGuide protocol. Clin Implant Dent Relat Res. 2010;12(Suppl 1):e104-13.

145 Meloni SM, De Riu G, Pisano M, Lolli FM, Deledda A, Campus G, Tullio A. Implant Restoration of Edentulous Jaws with 3D Software Planning, Guided Surgery, Immediate Loading, and CAD-CAM Full Arch Frameworks. Int J Dent. 2013;2013:683423.

146 Yong LT, Moy PK. Complications of computer-aided-design/computer-aided-machining-guided (NobelGuide) surgical implant placement: an evaluation of early clinical results. Clin Implant Dent Relat Res. 2008;10(3):123-7.

147 Rao W, Benzi R. Single mandibular first molar implants with flapless guided surgery and immediate function: preliminary clinical and radiographic results of a prospective study. J Prosthet Dent. 2007;97(6 Suppl):S3-S14. Erratum in: J Prosthet Dent. 2008;99(3):167.

148 Balshi SF, Wolfinger GJ, Balshi TJ. Guided implant placement and immediate prosthesis delivery using traditional Brånemark System abutments: a pilot study of 23 patients. Implant Dent. 2008;17(2):128-35.

149 Komiyama A, Hultin M, Näsström K, Benchimol D, Klinge B. Soft tissue conditions and marginal bone changes around immediately loaded implants inserted in edentate jaws following computer guided treatment planning and flapless surgery: a ≥1-year clinical follow-up study. Clin Implant Dent Relat Res. 2012;14(2):157-69.

150 Johansson B, Friberg B, Nilson H. Digitally planned, immediately loaded dental implants with prefabricated prostheses in the reconstruction of edentulous maxillae: a 1-year prospective, multicenter study. Clin Implant Dent Relat Res. 2009;11(3):194-200.

151 Abboud M, Wahl G, Guirado JL, Orentlicher G. Application and success of two stereolithographic surgical guide systems for implant placement with immediate loading. Int J Oral Maxillofac Implants. 2012;27(3):634-43.

152 Maló P, Rigolizzo M, Nobre Md, Lopes A, Agliardi E. Clinical outcomes in the presence and absence of keratinized mucosa in mandibular guided implant surgeries: a pilot study with a proposal for the modification of the technique. Quintessence Int. 2013 Feb;44(2):149-57.

153 Katsoulis J, Enkling N, Takeichi T, Urban IA, Mericske-Stern R, Avrampou M. Relative bone width of the edentulous maxillary ridge. Clinical implications of digital assessment in presurgical implant planning. Clin Implant Dent Relat Res. 2012;14(Suppl 1):e213-23.

154 Katsoulis J, Pazera P, Mericske-Stern R. Prosthetically Driven, Computer-Guided Implant Planning for the Edentulous Maxilla: A Model Study. Clin Implant Dent Relat Res 2009;11(3):238-245.

155 Schnitman PA, Hayashi C. Gingival Height and Bone Level in Response to Computer Assisted Implant Surgery and Immediate Restoration. J Oral Implantol epub ahead 2015.

156 Landazuri-Del Barrio RA, Cosyn J, De Paula WN, De Bruyn H, Marcantonio E Jr. A prospective study on implants installed with flapless-guided surgery using the all-on-four concept in the mandible. Clin Oral Implants Res 2013; 24: 428-433.

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