Basics of navigation implant prosthetics planning

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SUMMARY
Due to the development of digital technologies, the modern concept of prosthetic-guided implantology is based on non-invasive surgical and restorative techniques. Computer-aided planning, computer-guided workup and computer-guided surgery have largely ensured the predictability of the therapeutic outcome. This is supported by research data related to the frequency of implant therapy, according to which in the first half of 2020 there was an increase of 9.7%. However, anatomical limitations remain a challenge for the implant team. The most common problem related to implant therapy in edentulous patients is limited edentulous space in one or more spatial planes. Improving the design of surgical guides facilitates implantation in spatially limited and complex cases. By introducing interactive computed tomography into the field of implantology, a three-dimensional approach to every aspect of planning and implantation has become possible.

Keywords: prosthetic-guided implantology; computer-aided planning; computer-guided surgery

INTRODUCTION
Positioning implants according to the requirements of prosthetics, while respecting the capacity of bone structures and anatomical risk zones, requires detailed analysis and radiological visualization of a three-dimensional implant projection [1]. In order to ensure the optimal position of the implant, the procedure of “backward planning” is used in practice, i.e. implant placement according to prosthetic needs [2]. As the part of pre-surgical treatment, a clinician takes medical history, performs clinical examination, makes diagnosis, and plans the type and design of prosthetic restoration with an emphasis on the transmission of occlusal forces, as it dictates the number, type and position of implants. When creating a treatment plan, the clinician pays special attention to the quality of the remaining hard and soft tissue, which directs surgical positioning of the implants and subsequent bone remodeling. Clinical examination requires detailed extraoral, intraoral and radiographic analysis.

It is known that radiological diagnostics is the basis for planning implant therapy. The American Academy of Oral and Maxillofacial Radiology recommends conventional radiological methods as a starting point for planning [3]. Orthopantomography is used as part of the initial assessment of the patient, while intraoral radiograms are an additional element for a more accurate presentation of a particular segment. The main disadvantages of orthopantomography are: image deformation, which is 20-30% vertically and as much as 60-70% horizontally, supraposition of anatomical structures in the frontal region, lack of “third dimension”, as well as lack of information on bone quality [4, 5]. This implies that the precise creation of a surgical plan is not possible with two-dimensional radiographic methods and requires the use of cone beam computed tomography (Cone Beam Computer Tomography-CBCT). One of the most significant achievements in CBCT technology is interactive computed tomography (ICT) [6]. Most therapists agree that a correct diagnosis is the foundation of therapeutic success. In implant prosthetics, the foundations are defined by the precision of implant position. Ideal position of the implant is precisely planned spatial orientation in relation to the adjacent anatomical structures and/or the adjacent implant. Data on the comparison of the precision of the implant placement using conventional method of free-hand surgery and computer-guided implantation are available in the literature [7–9]. Table 1 shows the results of the research by Sun et al. [7].

According to the results, to meet these requirements, different static and dynamic navigation systems are available to clinicians. Due to the high costs of dynamic navigation, surgical templates are more widely used in practice as the main representatives of statically guided implant placement. Guides can be categorized according to different parameters. Based on the supporting tissues, they can be supported by teeth, bone or soft tissue structures, determined for toothless fields or edentulous jaws, depending on the indication [10]. The second division, based on materials for making surgical guides, refers mainly to self-bonding / light-curing acrylate resins, although they can be made of an alloy of CoCr and titanium. The third division of the guide refers to the design and can be open or closed [11, 12].

The aim of this paper is to present chronologically procedural planning steps in implant prosthetics with reference to the pre-prosthetic aspect of planning.

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CBCT provides the possibility of volumetric imaging of bones and preoperative collection of large amounts of information, of which the most important in toothless and edentulous jaws are: available bone volume and quality, position of anatomical structures and the presence of pathological changes [13]. Having in mind the oldest ethical principle of ancient medicine "primum non nocere (do not harm)" with the advent of modern methods of radiography, and in connection with the radiation dose, the so-called ALARA principle (As Low As Reasonable Achievable) was introduced, i.e. the application of the lowest possible radiation dose to obtain the characteristics of anatomical structures of interest [13]. The American Academy of Periodontology (AAP), by consensus in 2017, made recommendations for the rational use of CBCT radiography and panoramic radiography in oral and maxillofacial surgery [13]. As CBCT images have a high diagnostic capacity, the radiation dose for CBCT imaging per jaw is equal to 2 to 10 orthopantomograms. There are different sizes of fields of view depending on the indication. In the basic categorization, three types of fields of view are distinguished: limited (small), medium and large. The large field of view, which covers a wider anatomical region, requires a higher dose of radiation, creating an image of lower resolution. The limited field of view captures a small region, up to 15 cm, applying a lower effective dose of radiation, and provides a higher resolution image [14]. Reducing the radiation dose is achieved by choosing smaller recording volume, i.e. smaller FOV (Field Of View) [14]. Bornstein et al. [14] provided data for effective radiation doses (Table 2). Table 2 is provided with modifications from "Cone Beam Computed Tomography in Implant Dentistry: A Systematic Review Focusing on Guidelines, Indications, and Radiation Dose Risks" [14].

### ANALOG AND DIGITAL PLANNING

The preoperative segment of analog planning begins with the development of a diagnostic cast (Figure 1). Preliminary tooth placement on the diagnostic cast can be realized through the use of a set of fabricated PMMA teeth (set up) or by modeling the teeth in wax (wax up). The choice is a matter of the clinician's choice. However, there is a recommendation that factory-made teeth be used in edentulous patients, while wax modeling is easier to implement in cases of minor edentulousness [15]. Preliminary tooth placement on diagnostic model is the basis for making a radiological guide.

In a narrower sense, digital planning encompasses the domain of software tools of CBCT and CAD-CAM machines. The image created during the volumetric recording of the anatomical structures of the face and jaws is processed in the software program of the device in Digital Imaging and

### Table 1. Deviations of the longitudinal and angular position of implants comparing free hand guided and computer guided surgery

| Jaw Position | Jaw Type | Longitudinal Error (mm) Mean ± SD | Angular Error (degree) Mean ± SD |
|--------------|----------|-----------------------------------|----------------------------------|
| Maxilla Gorna | Eksperimental group (computer guided surgery) | 0.63 ± 0.24 | 3.07 ± 0.99 |
| Maxilla Gorna | Eksperimentalna grupa (komputerski navodena hirurgija) | 0.88 ± 0.22 | 3.59 ± 0.99 |
| Mandible Donja | Control group (traditional free hand surgery) | 1.21 ± 0.09 | 6.02 ± 0.04 |
| Mandible Donja | Kontrolna grupa (tradicionalna hirurgija vodena slobodnom rukom hirurga) | 1.63 ± 0.17 | 6.22 ± 0.09 |

### Table 2. Values of effective dose of CBCT radiation and panoramic radiography

| Study | Radiographic technique | Field of view | Effective dose |
|-------|------------------------|---------------|----------------|
| Theodorakou et al. | CBCT (< 40 cm²) | 4 × 4 cm² | 32 |
| Pauwels et al. | CBCT (< 40 cm²) | 5 × 3.7 cm² | 40 |
| Suomalainen et al. | CBCT (< 40 cm³) | 6 × 6 cm³ | 91 |
| Jeoung et al. | CBCT | 8 × 5 cm³ | 83 |
| Pauwels et al. | CBCT (<40–100 cm³) | 10 × 5 cm³ | 54 |
| Koivisto et al. | CBCT (<40–100 cm³) | 8 × 8 cm³ | 153 |
| Qu et al. | CBCT (<40–100 cm³) | 8 × 8 cm³ | 30/306/197 |
| Ludlow et al. | CBCT (< 100 cm³) | 16 × 6 cm³ | 74 |
| Ludlow et al. | CBCT (< 100 cm³) | 10 × 10 cm³ | 283 |
| Pauwels et al. | CBCT (< 100 cm³) | 15 × 15 cm³ | 194 |
| Okano et al. | CBCT (< 100 cm³) | 15 × 15 cm³ | 511 |
| Ludlow et al. | CBCT (> 100 cm³) | 20 × 20 cm³ | 1073 |
| Theodorakou et al. | Panoramic Ortopan tomografija | 15 × 10 cm³ | 6 |
| Silva et al. | Panoramic Ortopan tomografija | 15 × 11 cm³ | 10 |
| Carrafiello et al. | Panoramic Ortopan tomografija | 15 × 23 cm³ | 50 |
| Grünheid et al. | Panoramic Ortopan tomografija | 15 × 30 cm³ | 21.5 |
Communications in Medicine (DICOM) format [16]. The data thus obtained are combined with the data on the modeled wax-up. An important segment of planning includes the analysis of intermaxillary relations. With the introduction of the so-called Bari techniques the transfer of intermaxillary and occlusal relationships in all three spatial planes is enabled, and that in a digital environment. The method is based on the fabrication of a prosthetic stent that aims to transmit occlusal relations recorded by a temporary diagnostic prosthesis within the final prosthetic restoration on the implants [17]. Based on the above data, the therapist has clearly defined requirements for the prosthetic component and approaches virtual implant position planning including the length, diameter, inclination and depth of the implant. This is followed by the design of a surgical guide. Technological procedures for making surgical guides are divided into additive and subtractive (stereolithographic) methods [15].

**RADIOLOGICAL GUIDE FOR SUCCESSFULLY DESIGNED SURGICAL TEMPLATE**

The purpose of radiological guide is to enable the transfer of information about the position of the crown part of future restoration to the CBCT image. Good guide stability on supporting tissues is mandatory. Any imprecise fit can result in the conductor moving during radiography, resulting in displacement of the reference object. If the surgical guide is based on the information obtained that way, the clinician will find difficult to place the surgical guide and the entire procedure can be compromised [15]. In order to fulfill radiological visualization of prosthetic part of the dental compensation successfully, various radiopaque materials can be put within the radiographic guide. Numerous authors [15, 18] have compared opacity of the materials most commonly used for that purpose. The research results have shown that the biggest opacity has barium sulfate (BaSO₄), gutta-percha and the materials used for fixing the crowns based on zinc oxide. The radiological stent is most often made on a base of a master cast. The templates are made of hard vacuum foil of 1 mm in diameter. When it comes to edentulous patients, the old denture, if retained well on the supporting tissues, can also be used for the purpose of the radiographic guide. It is advised that adhesives should be applied on the mucosal side of the prosthesis before radiography as well. Perforations, in which the radiopaque materials are placed, are formed within acrylic teeth [19, 20]. The other option is fabricating the master cast based on complete denture.
The master cast represents the working cast for making the radiographic guide, most often of the vacuum foil [15].

**DYNAMIC AND STATIC NAVIGATION**

Dynamic navigation is computer-guided implant placement. This method refers to applying the intraoperative navigational system which constructional solution is usually based on the optical tools for measuring the position of the implants. Some of the currently available on the market are: Blue Sky Bio Plan Software, Fusion Nobel Biocare, CoDiagnostic software, M-Guide, DentalWings, Simplant Software, SMOP Swisseda etc. As indications for applying the dynamic navigation, Block and Emery have named mostly all those situations where relative or absolute restrictions to applying the surgical guide are possible: the patients with limited mouth opening, the implantation in hardly accessible regions of the side segments of the jaws, where mesiodistal dimension of toothless space does not allow placing the static guide due to the cylinder width [21]. The clinician follows on the computer screen moving of the surgical drill during the intervention [22]. The dynamic navigation advantages are: the cost-effectiveness procedure for the patient, the possibility of constant irrigation of the surgical area and more possibilities for the clinician to lead the surgical drill intraoperatively. The high expenses of tools are stated as the main disadvantage. The dynamic navigation is not advised as a part of the edentulous patient treatment [21]. The static navigation is based on applying the surgical template. The main function of the template is to enable transferring the analogous or digital therapeutic plan into three-dimensional intraoral surrounding. The vacuum foils, identical to those applied to the radiological templates, were used as the first guides. Such guide provides the insight into the future crown position, so, according to that, the surgeon can map the implantation place. Further implantation course is guided by the clinician and depends on his experience and skills.

Speaking of the contemporary static template, the implantation of virtually planned installation of the implants can be realized through semi-guided or fully guided and depending on the design of the sleeves (cylinders) which are integrated into the guide [15, 23, 24]. Fully guided surgery refers to applying the surgical template which design provides precisely planned position, angulation, diameter and implants’ depth. The template is placed in the patient’s mouth during the entire surgical procedure, not allowing the therapist to intraoperatively lead the drill to any other position apart from the one defined by the cylinders integrated within the guide. Due to the properties of the materials from which the templates are made (polymethyl methacrylate or metal alloys), as well as sleeves, which can be made from metal alloys or zirconium, rigidity of the guide is insured and therefore the greater safety for the clinician [15]. In order to provide greater safety during the procedure, the template should be retained well on the supporting tissues. This is also the reason why it is not justified to use poorly retained and old complete denture as the surgical template.

The term of semi-guided surgery refers to the templates that are in favor of the therapist only during the first implantation phases. These guides use cylindrical sleeves that can accept the first, and perhaps second surgical drill. When there is no enough space in the mesiodistal direction, the preference should be given to the sleeves for the semi-guided surgery since the cylinders have narrower diameter compared to fully guided surgery sleeves [15].

Fully guided approach has the advantage in cases of weak quality of the bone, considering that the light arm movement during the placement of the implants can result in greater deviation for the semi-guided surgery [24]. Considering the advantages and disadvantages of the both systems, the authors [24] who have analyzed the difference between fully and semi-guided surgery precision, have concluded that the statistically significant difference in accuracy is evident only in the position of the apical third of implants. The advantages of the fully guided surgery are: lower risk of anatomic structure damages, performing the surgical procedure without opening the flap (flapless surgery) and therefore shortening the postsurgical period of recovery, the possibility of individualization of the abutment design according to the surgical guide position etc [15]. However, even if the concept of applying the surgical guide considers simple protocol, these solutions contain certain disadvantages. Major ones are: insufficient surgical area visibility, impossibility of applying the surgical guide in case of the little inter-occlusal space, the risk of damaging or contaminating the drill when it passes through sleeve [23]. In order to compensate these disadvantages, nowadays the method of placing the implants applying the open guide has been considerably developing (TWIN-Guide®, 2Ingis, Brussels, Belgium). The open design compensates the mentioned disadvantages of the closed system of the guide, and it is compatible with all dental implant systems. Besides, surgical procedure is performed with continuous irrigation of the osteotomy site. The guide uses the pattern of the open frame, giving the clinician the guidelines for the implantation in the form of two reference cylindrical bushings places on the vestibular and oral sides of the surgical guide [23, 25].

**CONCLUSION**

Ideal position of the implants implies the spatial orientation in relation to adjacent anatomic structures and/or adjacent implants. Wrong positioning can have functional, technical, biological or esthetic consequences. Using computer-guided implantology provides predictability of the therapeutic results. Although the results of the wrong implant placement can lead to clinically manifested complications only in a few months or years, the first difficulties can arise even in the phase of impression taking when the deviation from the implant angulation prevents correct placing of the transfers. Wide ranges of surgical templates that differ according to the design and their purpose have enabled the clinicians to induce their purpose in the complex cases as well. Yet, the restrictions to the concept of the fully guided implantology are related
to its application only in the case of partially edentulous patients. The implant-prosthetic rehabilitation of the edentulous patients is realized by conventional methods partly or entirely guided by the surgeon.

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Osnove planiranja navigacije implantat-protetike

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KRATKI SADRŽAJ
Zahvaljujući razvoju digitalnih tehnologija, savremeni koncept protetskom nadoknadom vodenim implantologijom bazira se na neinvazivnim hirurškim i restorstvurnim tehnikama. Komputersko planiranje i komputerski vodena ugradnja implantata su u velikoj meri obezbedili preduvidnost terapijskog ishoda. U prilog tome govore podaci istraživanja vezanih za učestalost implantoloških terapija prema kojima je u prvoj polovini 2020. godine ostvaren porast za 9,7%. Međutim, anatomski ograničenja i dalje predstavljaju izazove za implantološki tim. Naičetiji problem u vezi sa implantološkom terapijom kod krezubih pacijenata je ograničen bezubi prostor u jednoj ili više prostornih ravni. Unapredijenim dizajnom hirurških vodiča olakšana je implantacija u prostorno ograničenim i kompleksnim slučajevima. Uvođenjem interaktivne kompjuterizovane tomografije u sferu implantologije, omogućen je trodimenzionalni pristup svakom aspektu planiranja i implantacije.

Ključne reči: protetskom nadoknadom vodenim implantologijom; komputersko planiranje; komputerski vodena ugradnja

UVOD

Pozicioniranje implantata prema zahtevima protetike, uz poštovanje kapaciteta koštanih struktura i anatomskih zona rizika, zahteva detaljnu analizu i radiološku vizuelizaciju trodimenzionalne projekcije moguće pozicije implantata [1]. Da bi se osigurala optimalna pozicija implantata, u praksi se koristi procedura „planiranja pozicije implantata unazad“ (eng. backward planning), odnosno ugradnja implantata prema protetkim po-trebama [2]. U okviru prehodirurškog trentmana, kliničar uzima anamnezu, vrši klinički pregled, postavlja dijagnozu i planira vrstu zubne nadoknade i dizajn protetike. Prilikom izrade plana terapije, postavlja dijagnozu, definisani preciznošću položaja ugrađenih konvencionalnih implantata [3, 4, 5]. Preciznost položaja implantata ugrađenih konvencionalnom metodom vodenja rukom hirurga (eng. free-hand surgery) i komputersko vodennom ugradnjom [7, 8, 9]. Prema rezultatima ovih istraživanja, postoji statistički značajna razlika u preciznosti položaja implantata.

Radi ostvarivanja zahteva preciznosti, kliničarima su na raspolaganju različiti sistemi statičke i dinamičke navigacije. Zbog velikih troškova dinamičke navigacije, veću primenu u praksi nalaze hirurški vodiči kao glavni predstavnici statički vodene ugradnje implantata. Vodići mogu biti kategorizovani prema različitim parametrima. Na osnovu nošćih tkiva, mogu biti podržani zubima, koštanim ili mekotkivnim strukturama, određeni za krezuba polja ili bezube vilice, zavisno od indikacije [10]. Cilj rada je da se prikaže hronološki procedurne korake planiranja u implantat-protetici sa osvrutom na predprotetski aspekt planiranja.

CBCT

CBCT daje mogućnost volumetrijskog snimanja kostiju i preoperativnog prikupljanja velikih količina informacija, od kojih su kod krezubih i bezubih vilica najznačajniji: raspoloživi volumen trodimenzionalne prostorije, dostupnost informacija o kvalitet kosti, položaj anatomskih struktura i/ili prvenstvo patoloških promena [13]. Američka akademija za parodontologiju (AAP) konsenzusom je iz 2017. godine dala preporuke za racionalnu primenu CBCT radiografije u oralnoj i maksilofacialnoj hirurgiji [10].
Kako CBCT slike imaju visok dijagnostički kapacitet, doza radijacije za CBCT snimak po vilici je kao za 2 do 10 ortopana. Postoje razlike u veličini vidnih polja zavisno od indikacije. U osnovnoj kategorizaciji razlikuju se tri tipa vidnog polja: ograničeno (malo), srednje i veliko. Veliko vidno polje, koje obuhvata širu anatomsku regiju, zahteva veću dozu zračenja, stvarajući sliku manje rezolucije. Ograničeno vidno polje obuhvaća malu regiju, do 15 cm, primjenjujući manju efektivnu dozu zračenja, i pruža sliku veće rezolucije [14]. Smanjenje doze zračenja postiže se izborom manjeg volumena snimanja, tj. manjeg FOV (eng. Field Of View) [14]. Autori [14] su dali podatke za efektivne doze zračenja (Tabela 2).

Preuzeto uz modifikacije iz „Cone Beam Computed Tomography in Implant Dentistry: „A Systematic Review Focusing on Guidelines, Indications, and Radiation Dose Risks” [14].

ANALOGNO I DIGITALNO PLANIRANJE

Preoperativen segment analognog planiranja započinje izradom dijagnostičkog modela (Slika 1). Preliminarna postava zuba na dijagnostičkom modelu može se realizovati kroz upotrebu garniture gotovih PMMA zuba (eng. set up) ili modelovanjem zuba u vosku (eng. wax up). Odabir je stvar izbora terapeuta. Ipak, postoji prepovrka da se fabrički gotovi zubi koriste kod bezubih pacijenata dok se voštanje modelovanje jednostavnije realizuje u slučajevima manjih krezubosti [15]. Preliminarna postava zuba na dijagnostičkom modelu je osnova za izradu radiološkog vodiča.

U užem smislu, digitalno planiranje obuhvata domen softverskih alata CBCT aparata i CAD-CAM mašina. Zapis koji na staje tokom volumetrijskog snimanja anatomskih struktura lica i vilica se obrađuje u softverskom programu aparata u formatu Digital Imaging and Communications in Medicine (DICOM) [16], Tako dobijeni podaci se objedinjuju sa podacima na izmodevom „wax-up“-u. Važan se pogled na planiranja obuhvata i analiza međuviličnih odnosa. Sa uvođenjem tzv. Bari tehnike omogućen je transfer intermaksilarnih i okluzalnih odnosa u digitalnom okruženju. Metoda se dobija po izboru terapeuta. Implantacija u trećem zubištu, kada se postavlja radio-opakni materijal [19, 20]. Druga opcija je izdvajanje zube izbaci radni model na osnovu za izradu radiološkog vodiča, najčešće od vakuum folije za izradu radiološkog vodiča, najčešće od vakuum folije za izradu radiološkog vodiča.

DINAMIČKA I STATIČKA NAVIGACIJA

Dinamička navigacija je kompjuterski voden ugradnja implantata. Ova metoda podrazumeva primenu intraoperativen i navigacionih sistema čije je konstruktirano rešenje uglavnom zainstalacije sa optičkim alatima za izračunavanje pozicije implantata. Neki od trenutno prisutnih na tržištu su: Blue Sky Bio Plan Software, Fusion Nobel Biocare, CoDiagnostic software, M-Guide, DentalWings, Implant Software, SMOP Swissseda...

Block i Emery su kao indikacije za primenu dinamičke navigacije naveli sve one situacije gde postoje relativna ili apsolutna ograničenja za primenu hirurških vodića: kod pacijenata sa ograničenim otvaranjem usta, implantacija na teško pristupacnim regijama bočnog segmenta vilica, situacije gde međuzalaznu dimenziju krozubog prostora ne dozvoljava stjanje statičkog vodiča zbog širine folije. Takođe, savetuje se nanošenje adheziva sa sluzokožne strane proteze pre stavljanja statičkog vodiča zbog širine folije (vodič)...

Terapeut prati kretanje hirurškog instrumenta u toku izvođenja intervencije na monitoru kompjuteru [22]. Prednosti dinamičke navigacije su: smanjenje troškova za pacijenta s obzirom na to da se sprovođi bez upotrebe hirurškog vodiča, mogućnost kontinuiranog hlađenja hirurškog polja, veće mogućnosti za kliničara kako je i stvarno usporedba hirurških instrumenti. Kao klinički nedostatak navode se veliki troškovi aparature. Dinamička navigacija se ne preporučuje u terapiji bezubih pacijenata [21]. Navigacija se bazira na primenom hirurškog vodiča. Osnovna uloga vodiča je da omogućuje uspostavljivanje novih prostora bez upotrebe hirurškog vodiča. Osnovna uloga vodiča je da omogućuje uspostavljivanje novih prostora bez upotrebe hirurškog vodiča. Osnovna uloga vodiča je da omogućuje uspostavljivanje novih prostora bez upotrebe hirurškog vodiča. Osnovna uloga vodiča je da omogućuje uspostavljivanje novih prostora bez upotrebe hirurškog vodiča.

Kao preporuka, za primenu statičkog vodiča, primjenjuju se ovrećni materiali: Dakar (cilindara) koje se integrisane u vodič [15, 23, 24]. Potpuno izolovan vodič je kada govorimo o savremenim statičkim vodićima, implantacija virtualno isplaniranog postupka ugradnje implantata može se realizovati kroz delimiticno (eng. half guided) ili potpuno voden ugradnju (eng. full guided) u zavisnosti od dizajna vodiča (cilindara) koje se integrisane u vodič [15, 23, 24]. Potpuno voden ugradnja podrazumeva primenu hirurškog vodiča čiji dizajn obezbeđuje precizno isplaniranu poziciju, angulaciju, dijametre i dubinu implantata. Vodič je isplaniran u usima.
pacijenta tokom cele procedure implantacije, ne ostavljajući mogućnost terapeuta da intraoperativno vodi instrument u bilo koji drugi položaj osim onog koji je definisan cilindrim integrisanim unutar vodiča. Zahvaljujući osobinama materijala od kojih su izrađeni vodiči (polimethylmetakrilat ili legure metala) i vodicama, koje mogu biti od legure metala ili cirkonije, osigurana je rigidnost stenta, a samim tim i veća sigurnost za terapeuta [15]. Da bi se dodatno obezbedila sigurnost u radu, vodič bi trebalo da bude dobro retiniran na bezubom grebenu. Ovo je ujedno i razlog zbog kojeg nije opravdano koristiti loše retinirane, stare totalne proteze kao hirurške vodiče.

Termin delimično vođene implantacije odnosi se na vodiče koji koriste terapeutu samo tokom početnih faza implantacije. Ovi vodiči koriste cilindrične vodice koje mogu prihvatiti prvo, i eventualno drugo hirurško svrdlo. Kada ne postoji dovoljno prostora u meziodistalnom pravcu, prednost treba dati vodičima za poluvođenu ugradnju s obzirom na to da cilindi imaju uži promjer u odnosu na cilindre za potpuno vođenu hirurgiju [15]. Potpuno voden pristup ima prednost u slučajevima sa slabim kvalitetom kosti, s obzirom na to da lagani pokret ruke tokom plasiranja implantata mogu rezultirati većim odstupanjem za poluvođenu ugradnju [24]. Kako oba sistema imaju svoje prednosti i nedostatke, autori [24] su analizirali razliku u preciznosti ugradnje implantata prilikom korišćenja delimično i potpuno vođene hirurgije, zaključili su da je statistički značajna razlika u preciznosti bila evidentna samo u poziciji apikalne treće vodilice [24]. Potpuno vodene hirurgije su: smanjen rizik od povrede anatomske strukture, izvođenje hirurškog pristupa bez odizanja režnja (eng. flapless surgery) i time skraćenje perioda postoperativnog oporavka, mogućnost individualizacije dizajna abatmenta prema poziciji hirurškog vodiča itd. [15].

Međutim, iako koncept primene hirurških vodiča podrazumeva jednostavan protokol za ugradnju, ovakva rešenja nose i nedostatke. Kao glavni, navode se nedovoljna preglednost operativnog polja, nemogućnost primene hirurškog vodiča u slučaju malog interokluzalnog prostora, opasnost od oštećenja ili kontaminacije svrdla prilikom prolaska kroz cilindar vodice [23]. Da bi se nadomestili pomenuli nedostaci, danas se uveliko razvija metoda ugradnje implantata primenom otvorenog vodiča (TWIN-Guide®, 2Ingis, Brussels, Belgium) [23, 25]. Otvoren dizajn kompenzuje navedene nedostatke zatvorenom sistema vodiča i kompatibilan je sa svim implantološkim sistemima. Takođe, sama implantacija sprovodi se uz kontinuiranu irrigaciju operativnog polja. Vodič koristi obrazac otvorenog okvira, dajući kliničaru smernice za implantaciju u vidu dve referentne cilindrične vodilice postavljene sa vestibularne i oralne strane rama hirurškog vodiča.

**ZAKLJUČAK**

Idealna pozicija implantata podrazumeva prostornu orijentaciju u odnosu na susedne anatomske strukture i/si susedni implantat. Pogrešno pozicioniranje može imati za posledicu funkcionalne, tehničke, biološke ili estetske posledice. Upotreom kompjuterski planirane i vođene implantologije može se obezbediti predvidljivost terapijskih rezultata. Iako posledice loše pozicije implantata mogu dovesti do klinički manifestnih komplikacija tek kroz nekoliko meseci, odnosno godina, prve poteškoće mogu nastati već u fazi realizacije otiska za zubnu nadoknadu kada odstupanje u angulaciji implantata sprečava pravilno plasiranje prenosnika. Veliki izbor hirurških vodiča, koji se međusobno razlikuju prema dizajnu i svojoj nameni, omogućio je kliničarima da indikuju njihovu primenu i u kompleksnim slučajevima. Ipak, ograničenja koncepta popunio vođene implantologije su u vezi sa njegovom primenom samo kod krezubnih pacijenata. Implantatno-protetska rehabilitacija bezubih pacijenata se realizuje konvencionalnim metodama delimično ili potpuno vodenim rukom hirurga.