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Article

Comparison of time required for guided implant site preparation with two different template designs and dedicated surgical kits: an in vitro study

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Abstract

Both types of surgical guides – with and without metal sleeves are founded beneficial in clinical studies. The aim of this in vitro study was to compare time of surgical procedure in dental implantology depending of used type of the surgical guide. Ten three dimensional (3D) printed models of lower jaws were prepared based on complete virtual model of patient clinical conditions with missing teeth 37, 46 and 47. Five of this models were used for implant sites preparation performed with use of surgical guide without metal sleeves and dedicated surgical kit, and next five were used for the same procedure performed with surgical guide with metal sleeves and dedicated surgical kit. Time of implant site preparation were measured and noted. Statistical analysis was performed using Student's t test for independent samples. Difference of time in both groups were founded as statistically significant ($t=-9.94$; $df=28$; $p=0.0000$). Type of surgical guide is important factor which can impact on time of implant site preparation and all surgical procedure.

Keywords: Digital guides, CAD/CAM, Metal Sleeves, Dental Implants, Time of Surgery.

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1. Introduction

Analysis of in vitro and in vitro studies, as well as systematic reviews, clearly lead to the conclusion that using individual CAD/CAM (Computer-aided design/Computer-aided manufacturing) guides may be the best way to achieve great accuracy and remain in line with the concept of prosthetically driven treatment plan in implant dentistry [1-6]. Stereolithographic surgical guides are also one of the most popular application of 3D printing in oral and maxillofacial surgery [7-9]. D'Souza divided implant guides for (a) non-limiting (b) partially limiting and (c) completely limiting design, where the completely limiting design group is most advanced and accurate [10]. Since 1992 when the concept of digital guides were introduced, today we can find three main kinds of digital implant templates designs in the completely limiting design group [11]:

1. Guide with main metal sleeves
2. Guide without metal sleeves- plastic only
3. Open frame plastic or metal guide

Most studies focused on the accuracy of guided surgeries concluding that surgical template without metallic sleeves are more accurate than those where metal sleeves are incorporated, and certain mention that the surgery time during guided implant surgeries is shorter comparing to the free hand approach [2-5,12-15]. On the other hands, other studies also show limitations of guided approach [1,6,16-18]. However, there is no literature comparing the time of surgery with different surgical template designs.

The aim of this in vitro study is to compare time of implant site preparation by means of use two different surgical kits designed to place the same tapered implants (TSIII, Osstem Implant, Seoul, South Korea) but for different template designs: plastic guide with and without metal sleeves.

2. Materials and Methods

The study was performed at the Department of Dental Propeadeutics and Prophilaxis, Medical University of Warsaw in July 2019. Model for the study was created at the basis of data collected for treatment a previously treated patient with missing teeth 37, 46 and 47. Data including DICOM (Digital Imaging and Communications in Medicine) files of patient CBCT (Cone Beam Computed Tomography) and digitalized gypsum model of soft tissue and teeth were imported into DDS-Pro software (JST, Częstochowa, Poland). Model was saved as STL (Standard Triangulation Language) file and 3D printed in ten copies in SLS (Selective Laser Sintering) technology with polyamide powder (SL01, Sondasys, Ogrodzieniec, Poland) in external printing center (Sondasys, Ogrodzieniec, Poland).

Figure 1. Guide design. Only diameters of guide holes were changed in the design between OGK (5,0 mm) and GKT (6,0 mm).

The DDS-Pro software was used to virtually plan appropriate implants (4.0x10mm) positions and design two types of surgical guides (Figure 1) according to the manufacturer recommendations, to be used with two different surgical kits for placement of tapered implants (TSIII SA Implants, Osstem Implants, Seoul, South Korea). A surgical template without metal sleeves was designed to be used with the OneGuide Kit (OGK, Osstem Implants), and a second surgical template prepared to incorporate dedicated metallic sleeve for 4.0 mm diameter implants (Green metal sleeve, Osstem

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Implants) to be used with the Guide Kit Taper (GKT, Osstem Implants). Three implants of 4.0 mm of diameter and 10 mm of length, were planned in positions 37, 46, and 47. Guides were designed in the same shape and the only difference between them was the diameter of holes specific for two different kits. The GKT required 1 mm more to bond a dedicated metal sleeve, after the surgical guide was printed. Both templates were 3D printed in external printing center (Natrodent, Łódź, Polska) using Multi Jet technology (MP3000, 3D Systems, material: supports S100, guide MP100, 3D Systems, Rock Hill, South California, US).

Ten printed models were randomly divided into two groups: five models each. First group was used with a guide with metal sleeves and GKT and the second group with sleeveless guide and OGK. The experiment consists in the simulation of implant site preparation. Three implant sites were prepared in each study model, according to the virtual plan and the manufacturer's instructions. Total of 30 implant sites were prepared: 15 sites in five models using the OGK and 15 sites in the another five models by using the GKT. Drilling procedures were done by the same expert operator with expertise of both surgical kits (Ł.Z.) with Implantmed surgical device (W&H Dentalwerk Bürmoos GmbH, Bürmoos, Austria) with 1200 rpm of speed and maximal torque under saline irrigation.

Figure 2. Comparison in number of tools required to prepare 4,0x10mm implant site with GKT (upper) and OGK (lower).

Time measurements for experiment were done with a digital stopwatch (iPhone 8, Apple Inc, Cupertino, US) between the start and end of the preparation process and noted within a hundredth of a second in Excel software (Microsoft Corporation, Redmond, Washington, US) by the same person (M.C.). Measured time includes process of changing tools and was noted for every single implant site independently for each implant site preparation. All the tools were stored in order of used surgical kit before each site preparation procedure. Amount of tools required for site preparation for an 4.0 x 10mm implant according to the manufacturer recommendation was not equal in both surgical kits. For sleeveless surgical guide (OGK) three surgical drills were used and for second surgical guide kit (GKT) five surgical drills and three metal reduction sleeves were used (Figure 2).

Comparison between time of preparation was analyzed using the Student's t test for independent samples (Statistica, StatSoft Polska, Cracow, Poland). A p value < 0.05 was considered significant. Results are shown as mean ± standard deviation, classic 95% confidence interval were calculated.

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3. Results

The table 1 presents results of statistical analysis. The mean time in the test group (without metal sleeves, OGK) was 99.63 ± 31.91 seconds and in the second group (with metal sleeves, GKT) was 207.81 ± 27.53 seconds.

Table 1. Results of basic statistical analysis

Sample	Sample size	Mean [s]	Minimum [s]	Maximum [s]	Standard deviation
OGK group – surgical guide without metal sleeves	15	99.63	64.77	153.66	31.91
GKT group – surgical guide with metal sleeve	15	207.81	175.73	273.82	27.53

The statistically significant differences between test group OGK and the control group GKT were verified with t-Student statistical test. The value t of the test was: t=-9.94 and degrees of freedom were df =28. The p value was lower than 0.05 (p=0.000), what proves that preparation time was statistically significantly lower in OGK group than in GKT group.

Figure 3. shows the differences in time of implant site preparation in two groups. Analysis of the box plots clearly shows that this differences are statistically significant.

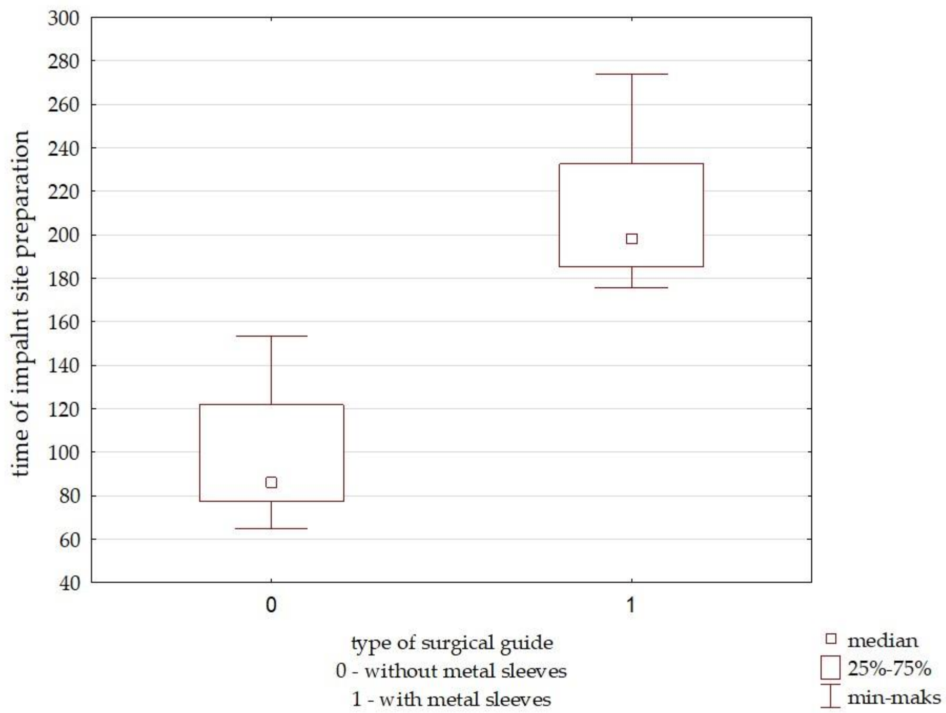

Figure 3. Comparison of data distribution depended on which type of surgical guide was used - group 0, without metal sleeves, OGK and group 1, with metal sleeves, GKT.

4. Discussion

This study focuses only on the time required for implant site preparation while besides of that part of surgery, other differ from different than guide design and surgical kits factors. Within this experiment all sites were prepared in the same conditions so only differences in surgical tools influent on the site preparation time. Our results show that implant site preparation with sleeveless guide and OGK is significantly shorter than with guide with metal sleeves and dedicated GKT. The standard deviations in time are similar in both groups, which proves that intra-groups differences are similar. Investigators found the lower number of surgical drills and replaceable elements as the crucial factor decided about reducing of implant site preparation time. In this experiment mistake when choosing appropriate tools from kits happened once when GKT were used while with OGK there were no mistakes.

Easier protocol of implant site preparation with sleeveless guide design and OGK brings lower risk of operator error which might increase safety of surgical procedures. The reduced number of surgical tools brings not only reduction of time during drilling part of the surgery but may also lower the risk of operator's or assistant's mistake and the same lower the total risk of surgery.

During experimental procedures another type of differences was observed between groups. Operator noted the differences in the dissipation of the heat. When the sleeveless surgical guide with dedicated surgical drills (OGK) were used, the problem with melting of study model material was less noticeable than when metal sleeved guide and dedicated drills (GKT) were used. Difference in heat generation using OGK comparing to GKT may be based on the drills design itself not on the guide design. Casetta et al. found that the clearance between drills and metal sleeves incorporated into plastic templates or even another clearance between drill and reduction sleeve may lead to the inaccuracies during surgery[19]. So it is hardly possible that high friction between main metal or reduction sleeves and drills may influent on temperature of the drill. Anyway this difference, when consider not only surgery time reducing, may influent on the invasiveness of implant surgery, and potential heat injury to the bone. Nevertheless temperature was not measured in this experiment and this founding based only on subjective evaluation of operator and observation of the models material cutting during performed procedures. To accurately compare heat dissipation between different kits another study should be perform.

In the RCT with a 100 implants placed, Tallarico et al. compared accuracy between the same two surgical guides design and kits (OGK and GKT) as we compared time of implant site preparation within this study [4]. He placed 41 implants with GKT and metal sleeves incorporated into plastic guide frame and 49 with OGK with plastic guide frame only, finding surgical templates without metallic sleeves were more accurate in the vertical plan and angle compared to the conventional template with metallic sleeves. Comparing requirements for these two kits preparation Tallarico and Zhou noticed that incorporating metal sleeve into 3D printed frame need one mm more interdental space to design the guide. As this fact has no side effect in our experiment planed in molar sites, that factor can make some limitations clinically when limited interdental space is available, e.g. premolars or lower incisors sites [4,20].

Besides more space requirements Cassetta et al. found, placing a prefabricated metal sleeve within the template can induce an error itself during the fabrication of a surgical guide, and as previously mentioned the clearance margins between the main sleeve and reduction sleeve for particular drill and between the reduction sleeve and the drill can result in inaccuracies during surgery [19]. Therefore, three-dimensionally printed surgical guides with in-built nonmetal sleeves of smaller diameter have been suggested by Schneider et al. for reducing lateral drill movements and instrument tolerances [14]. It is also important that when plastic only, 3D printed guide frame is used as a surgical template the device and 3d printing technology used for its manufacturing may be a key point for the accuracy [21,22]. The accuracy was found to be improved when using sleeveless design, in addition to it providing the advantage of having a buccal opening to facilitate drilling in the posterior region. Nevertheless so called side open sleeves are found to provide lower accuracy comparing to closed plastic sleeves in printed templates, but still higher comparing to freehand implantations [4,13]. On the other hand, side open sleeves without metal incorporated elements may be the only possible design to be apply in some clinical or anatomy limitations including mouth opening and interdental space [4,13,20].

(19, 20)Colombo et al. in a critical review based on randomized controlled trials regarding clinical applications and effectiveness of guided implant surgery concluded that reduction of surgical time and post-operative pain are discussed during guided implant surgeries. It is important to mention that the study is based on two RCT and in both bone or soft tissue stabilized implant guides were used, what means patients underwent extensive surgical interventions. In another RCT Tallarico et al. found higher post-operative pain and swelling at sites treated freehand comparing to these with guided approach [23]. The difference in patient postoperative experience in these studies may be based on the range of surgery itself. In general, surgery where extensive flap is elevated and guide is seated at the bone surface is more traumatic than mini flap, or flapless guided placement of single or multiple implants with a teeth supported guide[24]. It could be then no significant difference for the patient if extensive surgery is done guided or freehand and the same difference may be significant for less extensive surgery. Also accuracy of guided implant placement vary if that is a simple or complex surgery [6,19]. The same time required for accurate guide stabilization with bone anchors during extensive surgery may disappear when comparing time required to make similar surgery freehand without this process. Nevertheless, time of main surgery and implants sites preparation may be shorter with guided approach or even if the simple guiding devices are used [1].

As far as different surgeries required different time for preparation of operative field, anesthesia, flap reflections and template installation and fixation, guided approach provide increased accuracy during implant procedures [4,12,17-18].

There are limitations of this study. This is in-vitro experiment and drilling time within native bone may differ from drilling in the plastic models. But depending on the bone type or its hardness also drilling procedures in different sites or different patients can take different amount of time. There is almost sure that the absolute amount of time required for site preparation in the bone may be different than in plastic models [25]. Nevertheless, the results of this study suggest that using sleeveless guide with OGK may significantly reduce the time of implant site preparation comparing to sleeved guide and dedicated GKT. It can be important especially if multiple implants are placed during surgery.

Taking into consideration results of this study with all the limitations, we can conclude that, using 3D printed, plastic only guide with a dedicated OGK, require less time to prepare an implant site comparing to plastic guide with incorporated metal sleeve and dedicated GKT surgical set.
Besides all the intra surgical aspects of template based implant therapies this type of procedures are proceeded by carefully diagnostic process. Whole planning phase with use of CBCT images, scans of oral tissues and visualization of final restoration plan may be helpful tool during patient -doctor communication. Understanding the treatment plan and all benefits including: lower invasiveness, less pain, better precision and what this study supports shorter surgery time with digital supported implant therapy may be beneficial for reducing of fear and anxiety among patients [26,27].

5. Conclusion

With the limitations of this in vitro study, type of surgical guide seems to be an important factor which can impact on time of implant site preparation and all the surgical procedure.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, Ł.Z. and M.C.;

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