Effect of anchor-guiding sleeve length on accuracy of computer-guided implant surgery: a model study

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CONTENT

List of Figures

ABSTRACT

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The objective was to evaluate the effect of anchor guiding sleeve length on the accuracy of computer-guided flapless implant surgery in edentulous cases. Twelve identical polyurethane edentulous mandibular models were equally divided into the short and long sleeve groups based on the type of anchor guiding sleeve. After implants placement and scan bodies connection, digital impression was taken using the intraoral scanner. Using the software's measurement function, deviation parameters between planned and placed implants were calculated, and compared with the Mann–Whitney U test. In the short anchor guiding sleeve group, the median angular deviation 4.05°

(range, 2.87°–7.55°). Median linear deviation was 1.17 mm (range, 0.24–2.17 mm) for the implant apex and 0.82 mm (range, 0.43–1.67 mm) for the implant shoulder. Median deviation of the depth was 0.31 mm (range, 0.20–0.79 mm). In the long anchor guiding sleeve group, the median angular deviation was 2.70°(range, 1.77°–4.08°). Median linear deviation was 0.88 mm (range, 0.21–1.77 mm) for the implant apex and 0.63 mm (range, 0.11–1.97 mm) for the implant shoulder. Median deviation of the depth was 0.24 mm (range, 0.09–0.53 mm). There were significant differences between two groups in angular and linear deviations at the implant apex and the shoulder and depth deviation. The accuracy of muco-supported surgical guide may improve using the long anchor guiding sleeve, thus providing more accurate flapless implant placement in edentulous patients.

KEY WORDS: anchor guiding sleeve length; implant accuracy; computer-guided flapless implant surgery; edentulous cases.

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INTRODUCTION

Computer-guided implant surgery involves the use of a surgical guide that reproduces a virtual implant position designed from digitaldata.[1–4] The most important step in guided surgery is precisely positioning and stabilizing the guide because inaccurate placement of the template can lead to implant deviation.[5]To minimize the potential inaccuracy of guided flapless implant surgery in edentulous cases, Cassetta et al.[6] measured the accuracy of implant placement with and without fixation screws using muco-supported surgical guides in edentulous jaws. Results showed that implants placed with fixed guides had a higher accuracy, where the angular deviation was statistically significant (bias: with-4.09°; without-5.62°). They concluded that surgical guide fixation allowed greater transoperative stability, which reduced the potential inaccuracy between the planned and performed treatments. Vasak et al.[7] proved a correlation between the mucosal thickness at the implant site and the deviation degree, thereby demonstrating the negative impact of mucosal thickness on guide stability and reproducibility of positioning. This study suggested that accurate and stable positioning of surgical guides may be impeded in edentulous jaws by the mobile mucosal tissue. In addition, ridge atrophy makes placing the guide in the correct position difficult.[3–7] Stübinger et al.[8] used bone-supported templates using the open-flap surgical approach. Among all examined studies related to placement of dental implants in edentulous ridges, their study showed the lowest deviation and noted that using muco-supported templates resulted in a higher deviation compared to those applied in their study. However, they used the mucoperiosteal flap procedure with some disadvantages for computer-assisted implant surgery, particularly regarding trans- and postoperative morbidities. In contrast, the muco-supported guide has clinical advantages for flapless surgery of simplicity, causes less trauma to bones, less bleeding, shorter chair-time and postoperative pain, and less bone loss around the implant surface.[9]In that sense, previous studies have advocated the use of the muco-supported surgical guide for placing implants in edentulous patients.[2,5,6,10,11] Nevertheless, flapless surgery should be precisely applied using a surgical guide to overcome its limitations.

In an attempt to help seat the surgical guide more precisely on the edentulous mucosal tissue in flapless guided implant surgery, this experimental study was performed to determine whether the use of longer sleeves for fixing anchor screws leads to a more precise guide placement, thereby minimizing inaccuracy in guided flapless implant surgery. To the best of our knowledge, there have been no published reports on the role played by anchor guiding sleeves in improving the accuracy of implant placement when implants are placed on an edentulous ridge. Such a study would provide comprehensive information for the development of successful strategies to increase the accuracy of implant placement in edentulous patients. The purpose of this study was to evaluate the effect of anchor guiding sleeve length on the accuracy of computer-guided flapless implant surgery in edentulous cases.

MATERIALS AND METHODS

Twelve identical polyurethane edentulous mandibular models with a soft tissue replica were used. They were equally divided into two groups based on the type of anchor guiding sleeve. The short sleeve group contained 2.0 × 4.0-mm anchor guiding sleeves (DIO Implant Co., Pusan, Korea; Fig. 1A). The long sleeve group contained 2.0 × 8-mm anchor guiding sleeves (DIO Implant Co., Pusan, Korea; Fig. 1B).

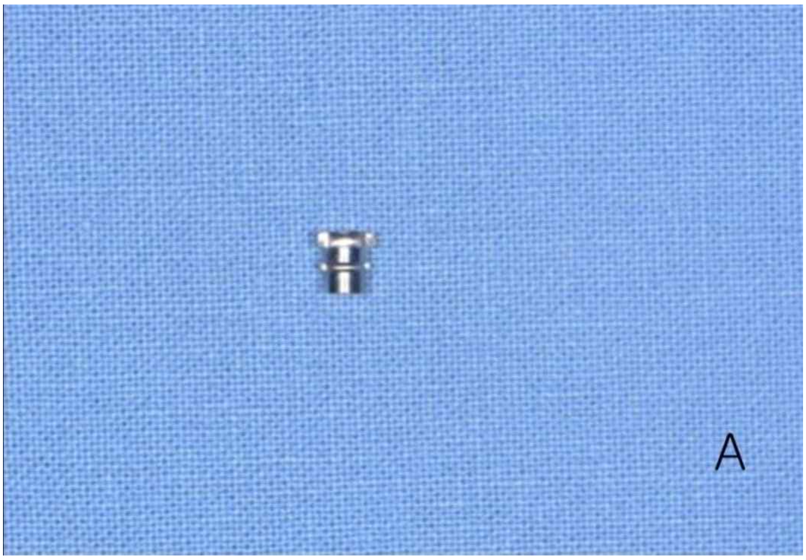

Fig. 1A. Implant sleeves length: short sample

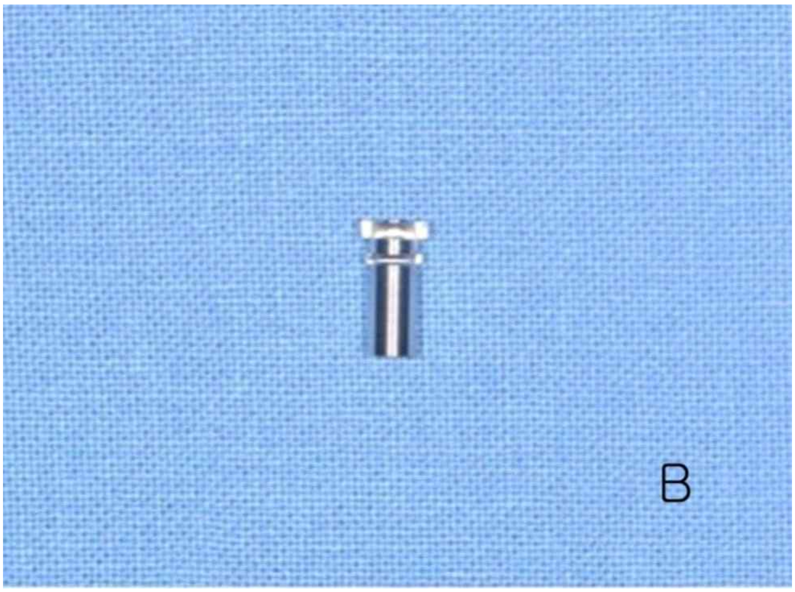

Fig.1B. Implant sleeves length: long sample

Implant Planning

After cone-beam computed tomography (CBCT) was performed on the model, it was scanned using an intraoral scanner (TRIOS; 3 Shape A/S Copenhagen, Denmark). Both digital files of STL generated by intraoral scanning and Digital Imaging and Communications in Medicine data obtained from the CBCT scan were imported into the software (Implant Studio; 3Shape A/S),using which virtual implant planning performed. The images of the CBCT data and the digital STL file were fused. After performing the image fusion, the implant position was planned using a virtual implant planning software. The implant positions determined were the canine, first premolar, and first molar regions, bilaterally. Once the implant location was determined, the surgical guide was designed on the intraoral scan that provided information on the implant position (Fig. 2). Holes for the long and short anchor guiding sleeves were also designed. The designed surgical guide was fabricated using a 3D printer (3D Printer Probe; DIO Inc., Pusan, South Korea; Fig. 3A,B).After fabricating the surgical guide, a bite registration putty was fabricated for surgical guide fixation by using a vinylpolysiloxane material and the surgical guide, along with the maxillary and mandibular models at the occlusal vertical dimension (OVD). The bite registration putty was fabricated by seating the surgical guide on the edentulous mandibular model, placing the vinylpolysiloxane interocclusal recording material (Bite Registration Creme of EXABITE II NDS; Alsip, GC America Inc., IL) between the surgical template and the occlusion surface of the opposing teeth, and further guiding the model to the OVD that was stabilized before the impression material was entirely polymerized (Fig. 4).

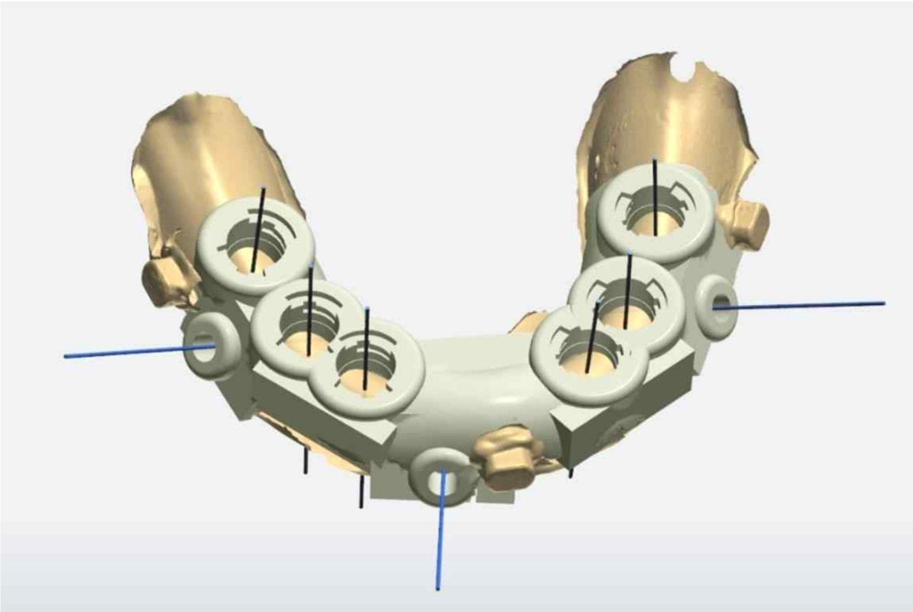

Fig. 2. Designing the surgical guide

Fig. 3A. Fabricated surgical guide: Short sleeve guide

Fig. 3B. Fabricated surgical guide: Long sleeve guide

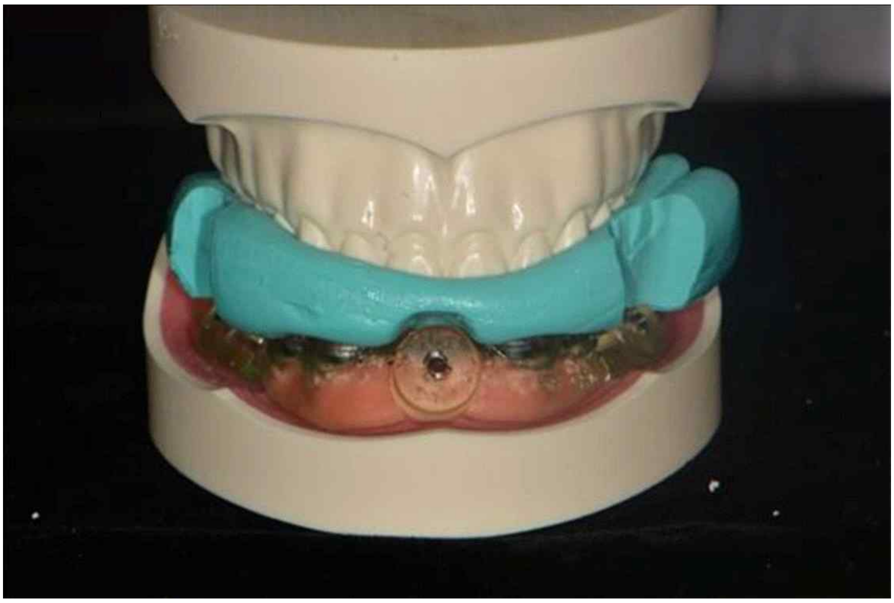

Fig. 4. Putty templates for jaws fixation

Implant placement

The surgical guide was placed on the edentulous model using the bite registration putty. Subsequently, drilling with an anchor drill was performed through the anchor guiding sleeve, and the surgical guide was fixed in place with an anchor screw (2.0 × 15 mm). After fixing the surgical guide, flapless implant surgery was performed using the surgical guide.

Accuracy measurements

After implant placement, the scan body (DIO Inc.) was connected to each implant, and a digital impression was taken using an intraoral scanner (TRIOS; 3 Shape A/S). The obtained STL files were imported in a software for file editing (3Shape Designer; 3 Shape A/S).The STL files of the corresponding inserted implants were then attached to each implant by perfect matching of the scan body, applying the best fit algorithm. Both the planned treatment data and digital impression data were imported in the file editing software. For measuring the deviation between the planned and placed positions of each implant, objects in both data were overlapped automatically using the file editing software. Using the software's measurement function, further deviation parameters were calculated between the planned and placed implants: angular deviation; linear deviation at the implant apex; linear deviation at the implant shoulder; and depth deviation (Fig. 5).

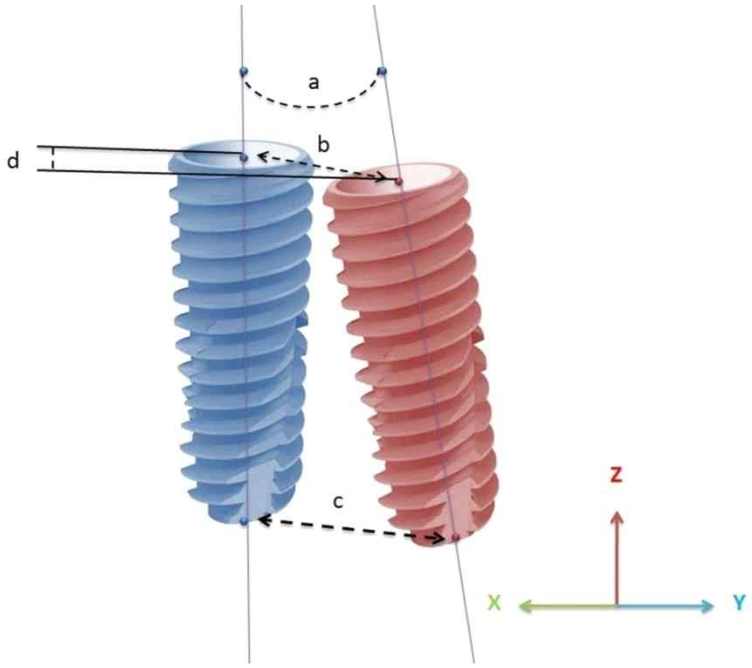

Fig. 5. Calculated deviation parameters between the planned and placed implants: a-angular deviation; b-linear deviation of implant shoulder; c-linear deviation of implant apex; d- depth deviation

Statistics

Differences between the two groups were calculated with the Mann–Whitney U test. A p-value <0.05 was regarded significant. Methodology was review by an independent statistician.

RESULTS

A total of 72 implants were inserted. Thirty-six implants were placed on six edentulous models using the surgical guides that contained the long anchor guiding sleeves whereas the other 36 implants were placed on another six edentulous models using the surgical guides that had the short anchor guiding sleeves. Implant surgery was performed by the same experienced oral surgeon.

In the short anchor guiding sleeve group, the median angular deviation was 4.05°(range, 2.87° to 7.55°). The median linear deviation amounted to 1.17 mm (range, 0.24 to 2.17 mm) for the implant apex and 0.82 mm (range, 0.43 to1.67 mm) for the implant shoulder. The median deviation of the depth was 0.31

mm (range, 0.20 to0.79 mm; Fig. 6A). In the long anchor guiding sleeve group, the median angular deviation was 2.70°(range, 1.77° to 4.08°). The median linear deviation amounted to 0.88 mm (range, 0.21 to 1.77 mm) for the implant apex and 0.63 mm (range, 0.11 to1.97 mm) for the implant shoulder. The median deviation of the depth was 0.24 mm (range, 0.09 to0.53 mm; Fig. 6B). There were significant differences between these two groups in the angular and depth deviations as well as in the linear deviation at the implant apex and shoulder.

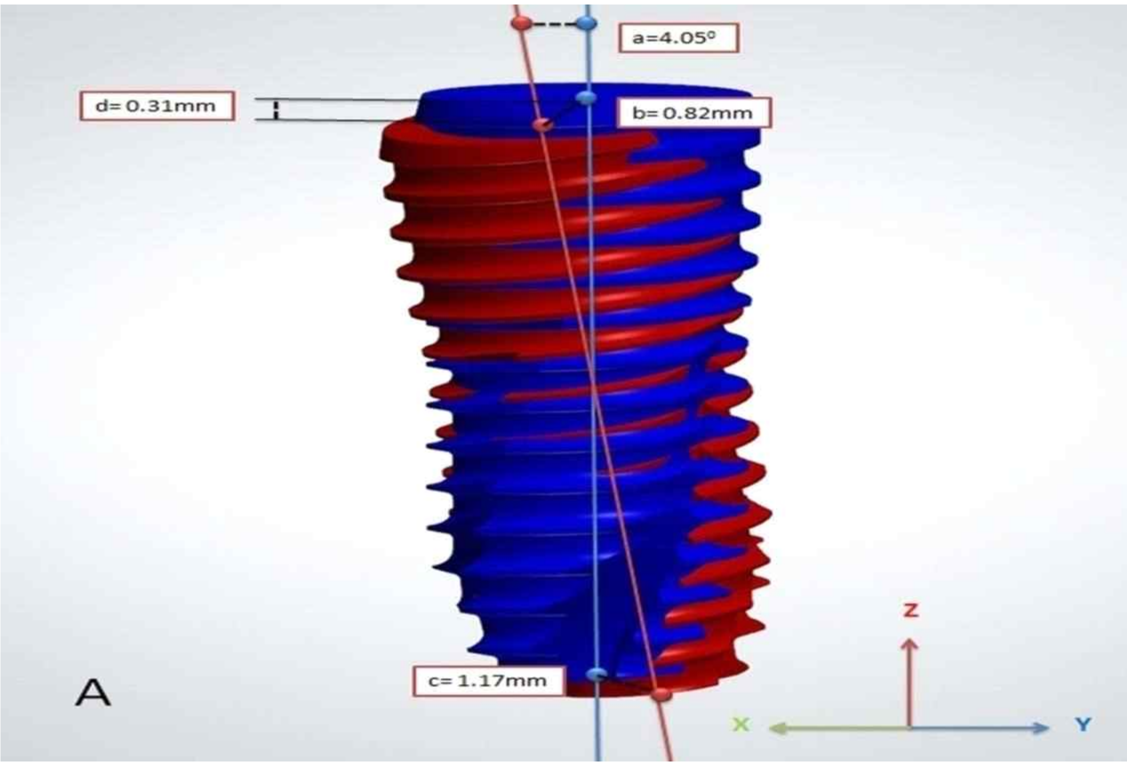

Fig. 6A. Average deviation parameters for the short anchor guiding sleeve group: a-angular deviation; b-linear deviation of implant shoulder; c-linear deviation of implant apex; d- depth deviation

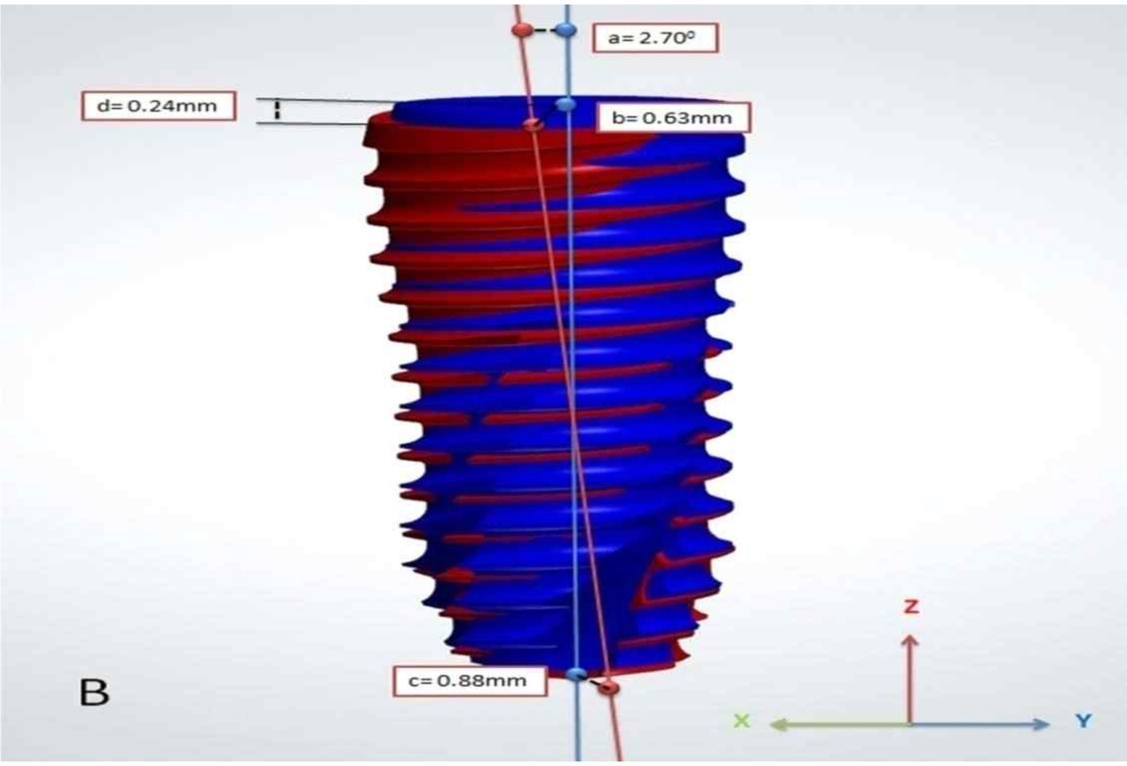

Fig. 6B. Average deviation parameters for the long anchor guiding sleeve group: a-angular deviation; b-linear deviation of implant shoulder; c-linear deviation of implant apex; d- depth deviation

DISCUSSION

This study showed a significant difference between the implants placed with short anchor guiding sleeves and those placed with long anchor guiding sleeves in terms of angular deviation and deviation in the position at the apex and platform. Our results suggested that an increased anchor guiding sleeve length has a considerably positive influence on the prevention of deviation during implant insertion in edentulous patients. Some studies demonstrated that that accuracy of muco-supported guides is significantly lower than bone-supported guide accuracy for implant placement in edentulous patients. Di et al.[5] used guides adapted to the mucosal surface and reported an angular deviation of 6.53°. Cassetta et al.[6] measured the accuracy of muco-supported surgical guides and reported an angular deviation of 4.09°. Valente et al.[12] reported an angular deviation of 7.9° with muco-supported surgical guides. Compared to those previous studies, the muco-supported surgical guides in our study showed significantly greater implant placement accuracy. The median angular deviation of implant placement with the long anchor guiding sleeve was 2.7°.

The higher accuracy of implant placement in this study may be due to the long anchor guiding sleeve that guided the anchor drill within the surgical guide. The anchor drill is important because it plays determinative role for the axis of the anchor screw. If any error occurs in the axis of drilling inside the bone, it becomes impossible to fix a surgical guide in the right position. Consequently, conditions of drilling for the anchor screw must be optimized to decrease the drill deviation. In our study, the long anchor guiding sleeve provided a long guidance for the anchor screw inside the implant guide, thus minimizing the drill's lateral movement. These findings are supported by the study by Choi et al.[13]who evaluated the effect of the surgical guide channel length on implant placement error in an in vitro study. They defined that the length of the channel was the main determinant in reducing the angular deviation of the implants and recommended using the longest possible channel to minimize deviation.[14]

Compared to bone-supported surgical guides, muco-supported surgical guides are disadvantageous for fixing surgical guides because mucosal resiliency in edentulous ridges can cause inconsistency in guide adaptation.[8,15,16] However, the use of a bite registration putty and a long anchor guiding sleeve provides an environment that allows the surgical guide to be seated and fixed on the edentulous ridges as precisely as bone-supported surgical guides. Stübinger et al.[8] and Vierira et al.[12] used bone-supported surgical guides and reported mean angular deviations of 2.39° and 2.31°, respectively. Therefore, it can be concluded that surgical guide fixation with long anchor guiding sleeves along with a bite registration putty can provide more accurate fixation of surgical guides, reducing errors between the planned and the placed implants.

There is a concern that surgical guides that contain long anchor guiding sleeves might interfere with the effective use of surgical instruments because the top of the hole holding a long sleeve is raised.[16] In our study, interference between the surgical handpiece and hole part of the surgical guide did not occur when drilling with the surgical guide was performed. This may be due to the fact that there was enough space between the anchor screw and the implant placement sites in the edentulous case.

Findings of the present study were derived from a model experiment. Therefore, further in vivo investigations on the effect of long anchor guiding sleeves are required to determine whether the results of this study are consistent with clinical findings.

CONCLUSIONS

In general, the results of our study demonstrated that the accuracy of muco-supported surgical guide may be improved by using the long anchor guiding sleeve, thus providing more accurate flapless implant placement in edentulous patients.

List of abbreviations used

CBCT: Cone Beam Computed Tomography

OVD - Occlusal Vertical Dimension

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ABSTRACT IN KOREAN(국문요약)

앵커 가이드 슬리브 길이가 컴퓨터 가이드 임플란트 수술의 정확도에 미치는 영향 : 모델 연구

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<지도교수: 최병호>

목표는 무치악 사례에서 컴퓨터 유도 플랩리스 임플란트 수술의 정확성에 대한 앵커 안내 슬리브 길이의 효과를 평가하는 것이었습니다. 12개의 동일한 무치악 하악 모델은 앵커 가이드 슬리브의 유형에 따라 짧은 슬리브와 긴 슬리브 그룹으로 균등하게 구분되었습니다. 임플란트 식립 및 스캔 바디 연결 후 구강 스캐너를 사용하여 디지털 인상을 촬영했습니다. 소프트웨어의 측정 기능을 사용하여 계획된 임플란트와 배치 된 임플란트 간의 편차 매개 변수를 계산하고 Mann-Whitney U 테스트로 비교했습니다. 짧은 앵

커 가이드 슬리브 그룹에서 중앙 각도 편차 4.05°(범위, 2.87°–7.55°). 중앙 선형 편차는 임플란트 정점의 경우 1.17mm(범위,0.24–2.17mm)이고 임플란트 숄더의 경우 0.82mm(범위,0.43–1.67mm)였습니다. 깊이의 중앙 편차는 0.31mm(범위,0.20–0.79mm)입니다. 긴 앵커 가이드 슬리브 그룹에서 중앙 각도 편차는 2.70°(범위, 1.77°–4.08°)였습니다. 중앙 선형 편차는 임플란트 정점의 경우 0.88mm (범위,0.21–1.77mm)이고 임플란트 숄더의 경우 0.63mm(범위,0.11–1.97mm) 였습니다. 깊이의 중앙 편차는 0.24mm(범위,0.09–0.53mm) 였습니다. 임플란트 정점과 어깨 및 깊이 편차에서 각도 및 선형 편차에서 두 그룹간에 유의 한 차이가 있었습니다. 연조직 지지형 수술 가이드의 정확도는 긴 앵커 가이드 슬리브를 사용하여 향상될 수 있으므로 무치악 환자에서 보다 정확한 절개가 필요없는 임플란트 식립을 제공 할 수 있습니다.

핵심단어 : 앵커 가이드 슬리브 길이; 임플란트 정확도; 컴퓨터 유도 플랩리스 임플란트 수술; 무치악 사례.