Accuracy comparison of implant position between using computer guided surgical stent and dynamic navigation system for implant placement: A preliminary study

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Abstract

Background: One of the important factors for the clinical outcome and long-term success of dental implants is the proper implant position related to prosthetic restorations. Advance digital computer technology can promote the proper implant position through the virtual implant planning system.

Objectives: To compare the precision of implant position placed by two different digital computer technology systems.

Materials and methods: Ten patients who need two implants supported fixed partial denture were randomly divided into two groups. The virtual implant positions were planed according to data from CBCT using coDiagnostiX software (Dental Wings Inc, GmbH, Germany) for computer guided surgical stent group and Iris–100 software (EPED Inc., Taiwan) for dynamic navigation group. At the time of surgery, implants were placed using either stereolithographic guide template or implant navigation system. Postoperative CBCT scan were taken and imported to the same implant planning software in each group in order to evaluate the deviations between planned and placed implant.

Results: A total of 20 implants were placed. The average angular deviations were 2.66°±1.15° and 2.66°±1.09°, the average platform 3D deviations were 1.00±0.63 mm and 1.17±0.54 mm, while, the average apical 3D deviations were 1.35±0.91 mm and 1.24±0.53 mm for computer-guided surgery group and dynamic navigation group respectively. Interestingly, there were no significant different between two groups.

Conclusions: This preliminary study demonstrated that the Computer-guided surgery and dynamic navigation system provided similar precision of implant position. Surgeon can select either guided or navigation system to provide proper implant position.

Keywords: accuracy, computer guided surgical stent, dynamic navigation system

Introduction

Implant placement with proper three-dimensional position is an essential fundament for functional restoration and esthetic outcome. These are the key to achieve clinical and long-term success of dental implants(Buser, Martin, & Belser, 2004).

Conventional method for implant placement is using the information that obtained from periapical or panoramic radiographs which does not provide enough three-dimensional data. Consequently, the clinical outcomes often show unpredictable result and may lead to malposition of implants followed by unwanted complications(Cooper, 2016)

In order to get rid of these limitations, digital computer technology such as computer- guided surgery or dynamic navigation system have been introduced to detailed in all three dimensions and simulation of virtually implant(Jung et al., 2009; Tahmaseb, Wismeijer, Coucke, & Derksen, 2014).

The computer-guided surgery can be performed by using guide stent fabricated by Computer-Aided Design/Computer-Assisted Manufacturing (CAD/CAM) technology. The data set from CBCT scan, surface scan were imported implant planning software in order to do the virtual implant planning and design the guided stent(Jung et al., 2009; Widmann & Bale, 2006).

In contrast, dynamic navigation is the system dentist can perform the surgery using an optical tracking system. The registration of the position of the patient and handpiece will be superimposed with CBCT image and present real time and guidance feedback of all drill steps on a monitor(Ewers et al., 2005).

Many studies reported the advantages of using digital technology in dental implant placement over conventional method(Farley, Kennedy, McGlumphy, & Clelland, 2013; Kramer, Baethge, Swennen, & Rosahl, 2005; Nickenig, Wichmann, Hamel, Schlegel, & Eitner, 2010). However, there are few numbers of clinical study that compared the accuracy of implant position between using computer-guided surgery and dynamic navigation system especially in partial edentulous patients needing two implants support fixed partial denture.

Thus, the aim of the present study is to compare the accuracy of implant position between two methods in partially edentulous patients needing two implants support fixed partial denture.

Materials and methods

Patients who have edentulous space (at least 3 months post-extraction) which require two dental fixtures support fixed partial prosthesis with including criteria as follow, adequate bone volume (including simultaneously implant placement with bone augmentation) and 20 years old and above were included in this study. The exclusion criteria were patients with uncontrolled systemic diseases or conditions that would affect osseointegration and / or healing process, limited mouth opening. All subjects (20 implants in 10 patients) were separated into 2 groups randomly with ratio of 1:1 using block randomization method: computer-guided surgery (n=10) and dynamic navigation system (n=10).

Preoperative CBCT scans were taken. In dynamic navigation group, a custom made vacuum stent attached with occlusal device composed of 4 radiopaque fiducial markers (IRIS-100, EPED Inc.) was placed in the patient mouth during CBCT scan and kept it for registration at the time of surgery.

Implant planning process

The implant planning for both groups was performed by one operator. The DICOM files from CBCT were imported into the coDiagnostiX 9.7 software (Dental Wings inc, Montreal, CA) for computer-guided surgery group or IRIS-100 software (EPED Inc., Taiwan) for dynamic navigation group in order to create the virtual implant planning. For guided surgery group, the STL file from surface scan was imported and merged with DICOM image, the virtual implant planning and guide template was designed and sent to laboratory for surgical guide production.

Implant placement

Only one surgeon with experience of implant placement performed all surgery. Straumann implants (Straumann, Basel, Switzerland) were placed under local anesthesia using surgical guide template or dynamic navigation system machine. For guided surgery, each surgical template was position into patient mouth and stability was checked before the surgery started. In dynamic navigation, the registration process including patient registration and handpiece registration are the process to identify position and motion of the drill and to identify the fiducials marker in surgical field to show the relation between the fiducial marker from CBCT image and patient's mouth.

Accuracy measurement

The preoperative and postoperative DICOM data were superimposed into the same coordination system, via the co-DiagnostiX™ software for guided surgery and IRIS-100 software for dynamic navigation group, then 3-

dimensional implant precision was measurement. Deviations were measured in three dimensions at the center of virtual and placed implant positions and axis.

The parameters of measurement are including; deviation of the axis (degree), deviation of 3D offset at platform(mm), deviation 3D offset at apical of implant(mm). (Figure 1)

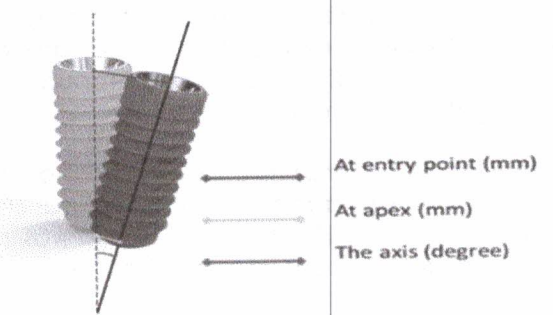

Figure 1 The parameters of measurement

Results

The average platform 3D deviations were 1.00±0.63 mm and 1.17±0.54 mm, while, the average apical 3D deviations were 1.35±0.91 mm and 1.24±0.53 mm and the average angular deviations were 2.66°±1.15° and 2.66°±1.09° for computer-guided surgery group and dynamic navigation group, respectively. (Table1and2)

Table 1 Deviation of implant position in computer-guide surgery group.

Sample	Tooth	3D Platform (mm)	3D Apical (mm)	Angle (°)
G1	25	0.78	0.86	0.50
G2	26	0.65	0.63	1.50
G3	16	2.32	3.44	2.32
G4	17	1.84	2.4	1.84
G5	26	0.37	0.62	2.30
G6	27	0.34	0.87	3.30
G7	25	0.88	1.21	3.60
G8	26	0.59	0.73	3.90
G9	36	1.14	1.11	3.70
G10	37	1.14	1.68	3.70
	Mean	1.00	1.35	2.66
	SD	0.63	0.91	1.15

Table 2 Deviation of implant position in dynamic navigation group.

Sample	Tooth	3D Platform (mm)	3D Apical (mm)	Angle (°)
D1	36	0.96	0.90	2.03
D2	37	1.66	1.68	2.33
D3	45	0.96	1.06	3.39
D4	46	0.49	0.53	1.25
D5	36	2.11	2.31	2.83
D6	37	1.40	1.10	3.40
D7	35	0.85	1.03	1.28
D8	36	0.41	0.71	4.40
D9	45	1.14	1.59	3.91
D10	46	1.72	1.48	1.81
	Mean	1.17	1.24	2.66
	SD	0.54	0.53	1.09

The data from the study was non-normal distribution in all data sets, therefore Mann–Whitney U test was used for comparison. There were no significant different of implant precision found between computer-guided surgery and dynamic navigation system.

Discussions

The appropriate implant position is the key to achieve clinical and long-term success of dental implants. The digital computer technology has been introduced to achieve detailed in all three dimensions for create the proper implant position. According to the results of this study, computer-guided surgery and dynamic navigation system provided similar accuracy of implant position.

The results of this study are similar to in vitro studies by Somogyi-Gnass et al(Somogyi-Ganss, Holmes, & Jokstad, 2015). No significant accuracy differences were found between using static and dynamic CAIS systems in partially edentulous maxilla and mandible human cadaver in range of mean platform and apex deviation was less than 1.91 mm and 1.14 mm, respectively. The mean angular deviation was less than 4.24 degrees for both systems.

Take together, it can be implied that computer-guided surgery and dynamic navigation system provide equal accurate and it can help clinicians to perform successful implant therapy.

Conclusion

This preliminary study demonstrated that using the computer-guided surgery and dynamic navigation system for implant placement provided similar accuracy of implant position. This result reflected accuracy can be achieved from both methods in patients needing two implants support fixed partial denture. Surgeon can select either guided or navigation system to provide proper implant position.

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