IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 14, Issue 7 Ver. VII (July. 2015), PP 62-65
www.iosrjournals.org

Computer Assisted Implant Surgery: Advanced Implant Surgical Technique

Srikanth Bitra[1], Marde Shraddha Kashinath[2], Rohit Kumar Kendole[3], Kotha Sunitha[4]

[1](*Department of Oral and Maxillofacial surgery, Bangalore Institute of Dental Sciences and Hospital, Bangalore, India*)
[2](*Department of Periodontology,Bangalore Institute of Dental Sciences and Hospital, Bangalore, India*)
[3](*Department of Oral Pathology & Microbiology, Government Dental College & Research Institute, Bangalore, India*)
[4](*Department of Oral Pathology & Microbiology,HKES's S. Nijlingappa Institute of Dental Sciences and Research centre,Gulbarga, India*)

Abstract: *Dental implants have gained wide acceptance in past few decades. The success of implant lies in successful osseointegration. The main challenge for successful osseointegration is proper treatment planning and accuracy in the surgical procedures. The ability of a surgeon to translate the ideal position of dental implant from diagnostic casts to anatomic landmark in the jaw determines the proper implant positioning. However, it is associated with increased failure rate due to lack in accuracy of stent fabrication and use of it during surgery. This led to the advances in imaging technology from 2 dimensional imaging to 3 dimensional imaging. 3 dimensional imaging using computer assists and guides the surgeon to carry out surgical procedures more accurately. Computer assisted surgery is widely accepted in many surgical specialities but its use in dentistry is not a reality till date. Hence this review is an attempt to provide an overview on computer assisted implant surgery (CAIS). Emphasis is placed on the steps in CAIS, advantages and disadvantages of the same.*
Keywords: *CAIS, Dental implants, Surgical advances*

I. Introduction

Surgical procedures in dental implants have not changed significantly since the invention of conventional osseointegrated implants. Universal key for success of implant is determined mainly by accurate positioning of implant placement. This depends on clinician's expertise to translate the ideal position of dental implant from the diagnostic tools like x-rays, CT, and CBCTscan to actual anatomic location in the jaw. The surgical stent acts as a 'translational guide'.However, inappropriate stent preparation, movement of stent during surgery, lack of reproducibility in terms of positioning the stent leads to imprecise implant placement and ultimately leading to implant complications and failure.

This led to the development of advances that can help the clinician determining ideal positioning of the implant. These advances includes a three dimensional (3D) computer image of the patient's jaw created from the computed tomography (CT) scan data,[1] computer generated surgical guides with drill sleeves[2,3,4] and the computer assisted implant surgery (CAIS) uses simultaneous tracking and "guidance" of the implant instrumentation to accurately follow the planned treatment during surgery.[5] Use of computer in dental implantology can be either using images traced by CT which are used to determine the patient's anatomic landmark in jaw using radiographic marker or by real-time ultrasound or contact probe 3D mapping.

II. Computer Assisted Implant Surgery (CAIS)

CAIS is the most sophisticated, highly precise, minimally invasive technique which can be time-saving as well.[6] This technique is performed without the use of CT or CBCT which prevents the radiation exposure. However, it requires highly expensive instrument set-up, clinician's expertise, highest amount of preparation and patient coordination. Initially the use of imaging was evolved in neuro-surgical procedures followed by multiple surgical fields[7,8] and now involving dental implantology as well. The real time safety control minimizes the surgical invasiveness thereby preventing unnecessary trauma and hence its use became widely accepted in all surgical branches. In dental implant surgeries, computer based surgery can be either using simple imaging software to visualize the implant position in 3D or by using more complex simultaneous image monitoring during surgery.[5] CAIS requires precise and continuous patient coordination of patient, image data and surgical instrumentation. For these criteria to be fulfilled there should be appropriatepatient alignment with patient's image data anda system that can track the movements of surgical instruments accurately.

2.1 Steps In CAIS[9] (Table 1)

2.1.1. Step 1: Data Acquisition:

Conventional methods of data acquisition includes use of CT, CBCT. However, it has got few limitations like radiation exposure, decreased accuracy by metal restorations, diffracted images and hence it later led to evolution of using spiral CT which minimized radiation exposure almost comparable to orthopantomograph and simultaneously maintains the diagnostic quality.[10] Use of CAIS requires radiographic markers which may be one of the two types, either natural like tooth or bone landmark or artificial like stents, screws, pins etc.

CAIS Immediate Mapping: Real time synchronization between 3D images and patient position and the possibility to adjust if any mistakes in synchronization are there, allows real time accuracy. This accuracy is the function of rigid body tracking system. This tracking system has deviation of 0.3mm.

2.1.2. Step 2: Identification And Registration

After data acquisition, 3D image is presented which needs to be identified and correlated with the jaw anatomy. This is done by using markers. Two important devices to capture actual point anatomy are touch pointer and ultrasonic probe. Operator uses touch pointer to touch anatomic points while the tracking device 'sees' the instrument and records each point. Ultrasonic probe is comparatively less accurate. However, it has advantages of being able to capture continuous data of bone morphology through gingiva or mucosa.

Matching of the geometry of image with patient's anatomy is called 'registration.' Methods used for registration include: 1. Point based, 2. Line or curve based, 3. Surface based, 4. Volume based and 5. Projective methods. Point based method makes use of certain points (artificial or natural markers) in pre-operative image data and patient anatomy. Points should be stable and easy to be measured. Operator manually clicks on points using tracking device. After matching the points, transformation equation is calculated using computer that minimizes the mean distance between matched points for registration. Three unaligned points are usually needed to avoid ambiguity. Hence, an equilateral tripod is preferred as it provides better results than threecollinear points in terms of accuracy.[11,12] The highly accepted and accurate algorithm is Hough transformation which measures distance between points and then compares itand uses it to find a triangle in intraoperative set of points which have equal edgelengths.[13] Following this, triangle points are then registered using best fit algorithm. After getting the first estimate of transformation, we can transform it to intraoperative points which has an average accuracy ranging from 0.5-1mm.[13] Line based or curve based method is evolved from point based method. It uses lines or curves. Errors are comparatively more in this method. All lines and surface measured on image planning and points on patient anatomy traced by tracking device collectively form the set of points but it is impractical to measure such a huge number of points.

2.1.3. Step 3: Navigation And Positional Tracking

Many navigation and positional tracking systemshave been developed these days but only few are widely accepted which meet the ideal requirements in terms of accuracy, reliability and clinical usability.[14,15]The "real-time" navigational technique is based on global positioning system.[16]In medical computer assisted surgeryfew technologies are used which includes mechanical, magnetic and optical tracking system. Mechanical system uses 6 axis coding robot with passive arm. It needs many markers and instruments. Therefore, not desirable for CIAS though it's accurate. Magnetic method requires magnetic source and a field receiver but it gets affected by metal things.[17,18] Hence not applicable in implant surgery as it includes metal instruments like drill. Optical method is well-accepted due to its accuracy. Vision plane is intersected between 2 or 3 cameras and is located with stereovision. Active and passive system function in two ways. A passive system absorbs and processes ambient light.An active system interprets reflected light. Infra-red light emitting diodes (IREDS) are widely used and very sensitive markers.[19,20] It is well accepted in medicine field, but its use in dentistry remains unexplored.[21,22] With this device, surrounding light in operatory plays acrucial role and a headset light is preferred with camera sensitive to natural light. Patient motion cannot be tracked unless markers are kept stable while surgery is being performed. If teeth are mobile or markers are not stable intraoperative cortical bone screws are alternatively preferred for use.

2.1.4. Step 4: Accuracy And Feedback

After the registration is obtained, instrumentation can be co-ordinated using 3D image of field of view on the monitor and accordingly surgical procedures can be performed.Instrument movement can be visualized on external monitor, which is present in the surgeon's field of vision.[23] Thus altogether the image on monitor, the surgical field, or the 3D projectionscreen guides the surgeon to carry out the surgery accordingly.

III. 2d Versus 3d Imaging

Side viewers provide 2D image and for that operator has to look away from the surgical site while performing surgery. See through viewers allows vision to the target field transparently and continuously. Augmented reality viewer provides 3D vision of superimposed surgical site binocularly.[24] Augmented reality method has few advantages like it is more natural and rapid but not more accurate than side viewer.[25] 3D imaging gives real 3D vision on a monitor without using operator glasses. 3D projection screens are either the multiplane device or a newer advanced technique using nanolenses.[13]

IV. Limitations Of CAIS

Holographic image is not possible because of a flat screen. However, it has a great advantage of providing a 3D 'real volumetric view.' Apart from this, 3D sequence of images can be modified for navigation. For example, 3D sequence of 8 views can be modified to facilitate the observation of a projected view of object at 90° with minimum head shift of only 5°. These real time, 3D front and side views provide intuitive 3D data views in spite of 2D parameters used to visualise them.[13]

V. Advantages And Disadvantages[13]

Advantages include:

1. Real- time 3D imaging and matching.
2. Immediate surgical procedures can be performedin most cases.
3. Minimally invasive and allows some cases to be treated flapless.
4. Preserves vital structure from injury by security stops.
5. Allows proper preoperative treatment plan.
6. Allows pre-operative and post-operative comparison.
7. Improves surgical skills of unexperienced surgeons.
8. Experienced surgeons can treat more challenging cases with more comfort and confidence and decreases time.

Disadvantages include:

1. Requires highest amount of preparation and patient coordination.
2. Expensive
3. High installation time
4. Needs proper training
5. Inaccurate data
6. Minimum three natural markers should be visible.

VI. Table 1: Steps In CAIS:

FOR CONVENTIONAL CAIS	FOR IMMEDIATE MAPPING
Data acquisition	Preparation for 3D mapping data acquisition
Identification	Chairside 3D mapping data acquisition
Registration	Navigation
Navigation	Accuracy
Accuracy	
Feedback	

VII. Conclusion

CAIS is a recent advanced technology which is highly accurate, precise, minimally invasive technique and prevents complications by providing intraoperative surgical 3D real-time visual assessment and thus resulting in proper placement of dental implants.It is a complex system that requires high coordination of several steps, clinician's expertise and requires extensive training. However, bringing this newer technique in practice will provide a way for implantologists to minimize the dental implant related complications and failures caused by malpositioning.

References

[1]. Verstreken K, Van Cleynenbreugel J, Martens K, et al: An imageguidedplanning system forendosseous oral implants. IEEE Trans Med Imaging 17:842–852, 1998.

[2]. Fortin T, Coudert JL, Champleboux G, et al: Computer-assisted dentalimplant surgery usingcomputed tomography. J Image GuidSurg1:53–58, 1995.

[3]. Klein M, Abrams M: Computer-guided surgery utilizing a computermilledsurgical template. PractProcedAesthet Dent 13:165–169, quiz170, 2001.

[4]. Sarment DP, Al-Shammari K, Kazor CE: Stereolithographic surgicaltemplates for placement of dental implants in complex cases. Int JPeriodontics Restorative Dent 23:287–295, 2003.

[5]. Casap N, Tarazi E, Wexler A, et al: Intraoperative computerized navigation for flapless implant surgery and immediate loading in theedentulous mandible. Int J Oral Maxillofac Implants 20:92–98, 2005.

[6]. Verstreken K, Van Cleynenbreugel J, Marchal G, et al: Computerassistedplanning of oral implant surgery: a three-dimensional approach.Int J Oral Maxillofac Implants 11:806–810, 1996.

[7]. Roberts DW, Strohbehn JW, Hatch JF, et al: A frameless stereotaxicintegration of computerized tomographic imaging and the operatingmicroscope. J Neurosurg65:545–549, 1986.

[8]. Satava RM: Emerging technologies for surgery in the 21st century.Arch Surg134:1197–1202, 1999.

[9]. Derycke R, Tracol JJ, Mongeot M, et al: La chirurgieImplantaire miniinvasive:unnouvelenvironnementclinique et de communication.Clinic2012. 6-19 November Special Issue.

[10]. Diederichs CG, Engelke WG, Richter B, et al: Must radiation dose forCT of the maxilla and mandible be higher than that for conventionalpanoramic radiography? AJNR Am J Neuroradiol17:1758–1760, 1996.

[11]. Fitzpatrick JM, West JB, Maurer CR, Jr: Predicting error in rigid-bodypoint-based registration. IEEE Trans Med Imaging 17:694–702, 1998.

[12]. Pennec X, Thirion JP: A framework for uncertainty and validation of3D registration methods based on points and frames. Int J Comput Vis25:203, 1997.

[13]. Carranza's Clinical Periodontology, 12th edition.

[14]. Brief J, Edinger D, Hassfeld S, et al: Accuracy of image-guided implantology. Clin Oral Implants Res 16:495–501, 2005

[15]. Widmann G, Stoffner R, Schullian P, et al: Comparison of the accuracyof invasive and noninvasive registration methods for image-guided oralimplant surgery. Int J Oral Maxillofac Implants 25:491–498, 2010.

[16]. Siessegger M, Schneider BT, Mischkowski RA, et al: Use of animage-guided navigation system in dental implant surgery in anatomicallycomplex operation sites. J CraniomaxillofacSurg29:276–281,2001.

[17]. Birkfellner W, Watzinger F, Wanschitz F, et al: Systematic distortionsin magnetic position digitizers. Med Phys25:2242–2248, 1998.

[18]. Birkfellner W, Watzinger F, Wanschitz F, et al: Calibration of trackingsystems in a surgical environment. IEEE Trans Med Imaging 17:737–742, 1998.

[19]. Kai J, Shiomi H, Sasama T, et al: Optical high-precision three dimensional position measurement system suitable for head motiontracking in frameless stereotactic radiosurgery. Comput Aided Surg3:257–263, 1998.

[20]. Malamas E, Petrakis E, et al: A survey of industrial vision systems:applications and tools. Image Vis Comput21:171, 2003.

[21]. Armangue X, Salvi J: Overall view regarding fundamental matrixestimation. Image Vis Comput1:205, 2003.

[22]. Chassat F, Lavallée S: Experimental protocols of accuracy evaluationof 6-D localizers for computer-integrated surgery: Application to fouroptical localizers. Lecture notes in Computer Science. Medical ImageComputing and Computer-Assisted Intervention-MICCAI'98 1496: 277–284, 1998.

[23]. Wanschitz F, Birkfellner W, Figl M, et al: Computer-enhanced stereoscopic vision in a head-mounted display for oral implant surgery. ClinOral Implants Res 13:610–616, 2002.

[24]. Zamorano LJ, Nolte L, Kadi AM, et al: Interactive intraoperative localization using an infrared-based system. Neurol Res 15:290–298, 1993.

[25]. Tian X, Ling KV, Ng WS: Magnetic tracker calibration for an augmentedreality system for therapy. ProcInstMechEng [H] 215:51–59,2001.