Accuracy Using Static or Dynamic Navigation

Navigation is used for dental implant placement for several reasons: (i) to avoid important structures such as the inferior alveolar nerve, (ii) to minimize flap mobilization in order to achieve minimally invasive surgery, (iii) to accurately place multiple implants with proper spacing and angulation, (iv) to place single implants in exact locations when access is minimal and when the esthetic needs are high. Navigation allows prosthetic / surgical collaboration with precise planning and accurate orchestration of the plan to achieve ideal patient specific results. The following references provide evidence based information concerning accuracy of two navigation methods.

1. Farley NE, Kennedy K, McGlumphy EA, Clelland NL. Split-Mouth Comparison of the Accuracy of Computer-Generated and Conventional Surgical Guides. Int J Oral Maxillofac Implants; 2013; 28:563-572
   Even with the aid of a laboratory-fabricated guide which is not true guidance, the error with the free-hand approach is greater in all measured parameters.

2. Arora KS, Khan N, Abboudi H, Khan MS, Dasgupta P, Ahmed K. Learning curves for cardiothoracic and vascular surgical procedures - a systematic review. Postgrad Med. 2015; 127:202-214
   Navigation surgery is known to have a learning curve associated with it. The learning curve of cardiothoracic and vascular surgical procedures (38) has been summarized in a total of 48 studies. Based on operating time, the learning curve for coronary artery bypass surgery ranged between 15 and 100 cases.

3. Koch AD, Ekkelenkamp VE, Haringsma J, Schoon EJ, de Man RA, Kuipers EJ. Simulated colonoscopy training leads to improved performance during patient-based assessment. Gastrointest Endosc. 2015; 81:630-636
   Simulation of dynamic navigation has been used to decrease the learning curve for clinicians performing colonoscopy. Simulators improved training of novice endoscopists.

4. Casap, N., Wexler, A., Persky, N, Schneider, A, Lustmann, J. Navigation surgery for dental implants: Assessment of accuracy of the image guided implantology system. J. Oral Maxillofac. Surg. 2004; 62:116-119
   Studies on models indicate that dynamic navigation systems have mean entry deviation approximating 0.4 mm and mean angular deviation error approximating 4 degrees. These studies, simulating dynamic navigation, indicate very accurate implant placement.

5. Luebbers, H.-T, Messmer P, Obwegeser JA, Zwahlem RA, Kikinis R, Graetz KW, Matthews F. Comparison of different registration methods for surgical navigation in cranio-maxillofacial surgery. J. Craniomaxillofac. Surg. 2008; 36: 109-116
   Deviations from the predetermined plan can be seen in "real time" and changes to the plan can be made at the time of surgery. Surgeons are not forced to abandon a plan should they desire to make a change. Full guidance is possible as real-time visualization and adjustment of position can be made at any time.

6. Casap, N., Wexler, A. & Eliashar, R. Computerized navigation for surgery of the lower jaw: comparison of 2 navigation systems. J. Oral Maxillofac. Surg. 2008; 66: 1467-1475
   Tracking of the lower jaw using tooth retained fiducial markers, was found to be superior to indirect tracking. They concluded that a computerized navigation system using a teeth-mounted sensor frame and teeth-supported fiducial markers enables more accurate navigation for surgery of the lower jaw.

7. Tahmaseb A, Wismeijer D, Coucke W, Derksen W. Computer Technology Application in Surgical Implant Dentistry: A Systemic Review. Int J Oral Maxillofac Implants. 2014; 29 (SUPPL):25-42

8. Jung RE, Schneider D, Ganeles J, Wismeijer D, Zwahlen M, Hammerle CHF, Tahmaseb A: Computer technology applications in surgical implant dentistry: A systemic review. Int J Oral Maxillofac Implants 2009; 24(suppl): 92-109
In two meta-analyses, with static guides, there was a mean deviation of 1.04 mm (up to 4.5 mm) at the entry point, and 1.4 mm (up to 3.75 mm) deviation at the implant's apex. Analyses using free-hand methods were model based and showed less accuracy compared to navigation.

9. Scherer U, Stoetzer M, Ruecker M, Gellrich NC, von See C. Template-guided vs. non-guided drilling in site preparation of dental implants. Clin Oral Investig. 2015; 19(6):1339-1346
On porcine jaws, template guided implant placement was found to be more accurate than freehand methods.

10. Vercruyssen M, Cox C, Coucke W, Naert I, Jacobs R, Quirynen M. A randomized clinical trial comparing guided implant surgery (bone- or mucosa-supported) with mental navigation or the use of a pilot-drill template. J Clin Periodontol. 2014; 41:717-723
There is a difference in accuracy between clinicians. Some clinicians are more accurate with CT guided implant placement than others, regarding the positions of the apex, depth, and angle. When inexperienced surgeons were supervised by experienced surgeons, there was no significant difference between inexperienced or experienced surgeons regarding implant placement accuracy when using CT-generated stents.

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