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IADR GENERAL SESSION
BOSTON, MASS., USA • MARCH 11-14, 2015

IADR/AADR/CADR General Session & Exhibition Boston, MA, USA March 11-14 2015

 # 2993

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Precision of Computer-guided Implant Placement in the Edentulous Mandible - an In-vitro Study

Objectives

Patients and providers nowadays demand functional and esthetic implant borne dental prosthesis. Restorative-driven implant placement requires continuous diagnostic treatment planning before the surgery. The implant design and position can be planned digitally using a CT or CBCT scan with a radio-opaque stent as well as special software [1]. The aim is to make a surgical template for guided, and therefore predictable, implant placement. However, positioning and stability of tissue-supported templates might be challenging.
This in-vitro study compares the precision of different implant planning software programs in combination with the corresponding surgical templates regarding implant position in the edentulous mandible.

Material and Methods

Thirty radio-opaque resin-based mandibles with elastic mucosa (n=30) were used (Fig. 1). The mandibles were prepared in a standardised manner for six reference pins made from titanium (Ø1,5mm Titanium wire, Gemmel Metalle, Döbeln, DE; Fig. 2). Three different manufacturers were asked to provide 10 of their system-specific radio-opaque stents as well as the corresponding implant-planning software programs: 1. SimPlant (Materialise Dental, Leuven, BE; Fig 3), 2. coDiagnostiX (Straumann, IVS Solution AG, Chemnitz, DE; Fig. 4), and 3. SKYplanX (Bredent, Senden, DE; Fig. 5).

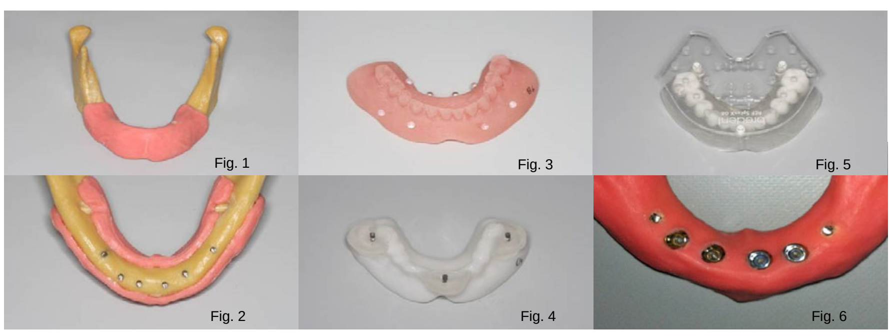

Fig. 1: Mandible with simulated resilient tissue; Fig. 2: Six titanium reference pins; Fig. 3: Stereolithographic radio-opaque stent (SimPlant, Materialise, BE), Fig. 4: Conventional radio-opaque stent (coDiagnostiX, Straumann, IVS Solution AG, Chemnitz, DE); Fig. 5: CAD/CAM radio-opaque stent (SKYplanX, Bredent, DE); Fig. 6: Guided implant placement

The CT scans (Multisclice Somatom Sensation, Siemens, DE) were conducted following a standardised protocol [1,6] using a special Styrofoam dummy to position the mandibles in a reproducible manner (Fig. 7-9).

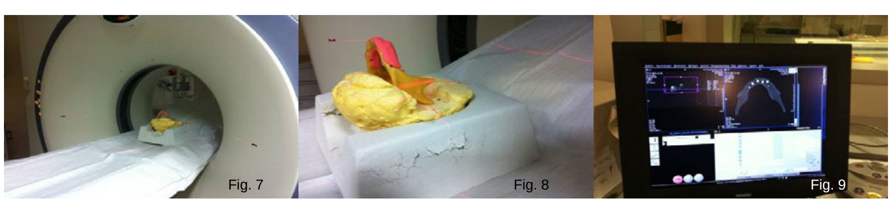

Fig. 7-9: Multislice Somatom Sensation (64 line configuration) with the styrofoam dummy and the used parameters

Each system was used to virtually plan 4 implants (Standard plus, RN, Ø4,1mm, l=10mm, Straumann, Basel, CH) in tooth positions 21, 23, 26 and 28. Measurements of the distances from the virtual implant shoulder and the apex to each reference pin were recorded (Fig. 10, 11-13).

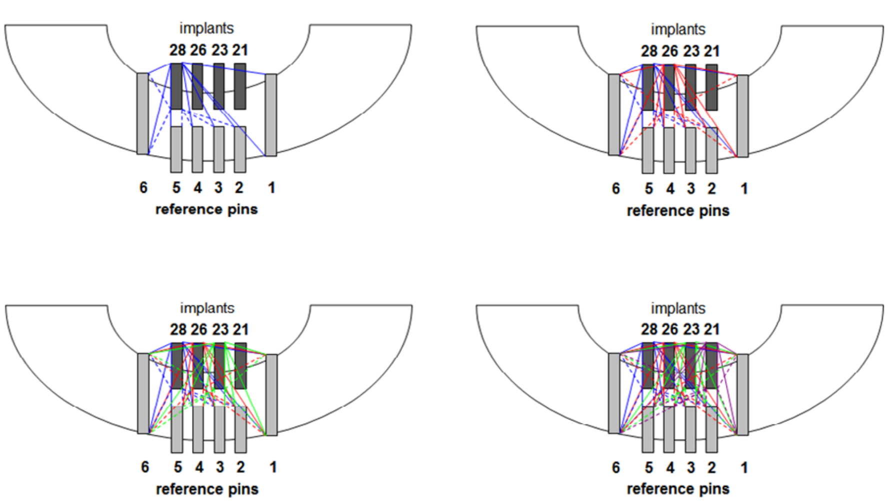

Fig. 10: Schematic drawing of the distances measured from every implant (#21, 23, 26, 28) shoulder and apex to each reference pin (1-6)

The manufacturers provided the appropriate surgical stents according to the guided surgery implant system with standard sleeves 5mm in diameter (Straumann, fig. 14-16). One-hundred and twenty implants were placed by the same operator strictly following the recommended surgical protocol (Fig. 6, 17-19). Final CT scans were made, and the measurements of the resulting implant position were repeated using the appropriate planning software and the same distances in the identical CT slice (Fig. 20-22). The data were normally distributed (Kolmogorov-Smirnow-Test), and therefore the t-test was applied, setting the p-value at $p<0.05$.

Fig. 11-13: Digital planning with SimPlant; coDiagnostiX , SKYplanX;
Fig. 14-16: Surgical stents of SimPlant, CoDiagnostiX , SKYplanX;
Fig. 17-19: Implant placement with SimPlant, CoDiagnostiX , SKYplanX;
Fig. 20-22: Final measurements with SimPlant, CoDiagnostiX , SKYplanX

Results

The mean values and standard deviation of the measurements were calculated from the neck and the apex of each implant to each reference pin (Fig. 24). The placed implants had the highest deviation at the shoulder and the apex for SimPlant (shoulder 0.61±0.19mm, apex 0.71±mm) followed by coDiagnostiX (shoulder 0.55±0.25mm, apex 0.45±34mm), and the lowest deviations for SKYplanX (shoulder 0.47±0.14mm, apex 0.38±0.08mm). There was no significant difference between pre- and post-operative measurements (SimPlant p=0.14; coDiagnostiX p=0.2; SKYplanX p=0.31) or between the three systems (p=0.267).

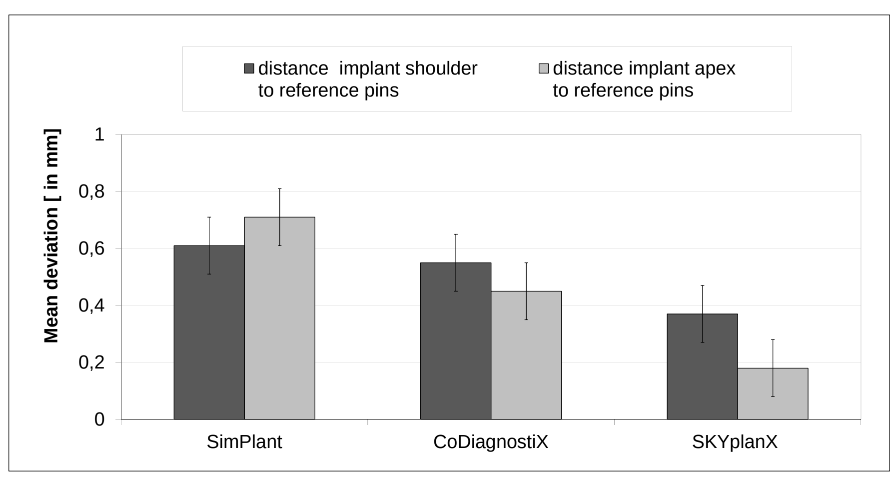

Fig. 23: Mean deviation (in mm) for distances from implant shoulder and apex to the reference pins

The results of this in-vitro study differ from data in the recent literature about computer-guided implant surgery. Particularly, clinical studies have proven higher deviations: Van Assche et al. [5] tested different, alternative systems and measured higher mean deviations for the implant shoulder (0.99mm) as well as for the apex (1.24mm). The results by Lee at el. [3] were even more dramatic: mean deviations at the coronal center were 1.09mm and at the apical center 1.56mm. Furthermore, Ochi et al. [4] also found the higher mean deviations that occur clinically, with 0.89mm at the shoulder and 1.08mm at the apex. On the other hand, one clinical trial by Komiyama et al. [2] showed comparable results to the current study (shoulder 0.59mm and apex 0.39mm).

Conclusion

The results of this in-vitro study show low deviation for the three software programs between planned and actual implant position. The precision of the different systems and methods seem to be adequate. However, clinical studies do not comply with this conclusion [3-5]. Thus, the accuracy of guided implant placement in the edentulous mandible depends on the stability of the surgical stent.

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