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.

The 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.

Materials 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), coDiagnostiX (Straumann, IVS Solution AG, Chemnitz, DE; Fig. 4), and 3. SKYplanX (Bredent, Senden, DE; Fig. 5).

The CT scans (MultiSlice 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).

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).

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 positions 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-Smirnov-Test), and therefore the t-test was applied, setting the p-value at p<0.05.

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 ± 0.20mm) followed by coDiagnostiX (shoulder 0.55 ± 0.25mm, apex 0.45 ± 0.34mm), 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).

The following diagram shows the deviations in millimeters from the implant shoulder and apex to each reference pin.

![Diagram showing deviations from implant shoulder and apex to reference pins](image)

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.