AAID Foundation Final Large Research Grant Report

**Grant Report Instructions:** The report should not be longer than 10 pages in length. The page limit does not include the draft JOI manuscript.

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**Project title:** Accuracy of Different Surgical Guide Designs for Static Computer-Assisted Implant Surgery: An in vitro Study

**Grant Period:** 1/1/2020-12/31/2022

**Objectives:**

The aims of this study were to evaluate the effect of (i) different surgical guide designs and (ii) implant placement location on the 3D accuracy of guided implant placement in single edentulous sites. The null hypotheses of this study were that in fully guided implant surgery, there is no difference in the angle and 3D offset at the base and tip using different surgical guide 86 designs and in different implant locations.

**Project Results:**

All implants were placed uneventfully. The overall mean and standard deviation angle were 2.91 ± 1.48, 2.86 ± 1.33, and 2.54 ± 1.11° for groups 1, 2, and 3, respectively. The overall mean and standard deviation for 3D offset at base were 0.63 ± 0.21, 0.55 ± 0.22, and 0.48 ± 0.18 mm for groups 1, 2 and 3, respectively. The overall mean and standard deviation for 3D offset at tip were 1.08 ± 0.44, 1.01 ± 0.44, and 0.85 ± 0.33 mm for groups 1, 2 and 3, respectively.

Table 1 presents the results of the angular deviation by group and subgroup. In the analyses of simple main effects, there was a statistically significant difference between the groups for implants #4, #7, and #14 ($p<0.05$), but not for implant #9 ($p=0.238$). Post-hoc tests showed a statistically significantly higher deviation for group 2 compared to group 3 for implants #4 ($p=0.016$) and #7 ($p<0.001$) and statistically significantly higher deviation for group 3 compared to group 2 for implant #14 ($p=0.025$). There was also a statistically significantly higher level of deviation for group 1 compared to group 3 for

implant #7 (p=0.005). The within-group comparisons of angular deviations between the different implants demonstrated no statistically significant difference in group 1. For group 2, there was a statistically significant difference between the implants (p<0.001). Post-hoc tests showed a statistically significant difference between implants #4 and #9 (p=0.0079) and #7 and #9 (p=0.003). For group 3, there was a statistically significant difference between the implants (p<0.001). Post-hoc tests showed a statistically significant difference between implants #4 and #9 (p<0.001), #4 and #14 (p=0.001), #7 and #9 (p=0.003), and #7 and #14 (p<0.001).

*Table 1*. Results for the angle deviation (in degrees; n=15 per group)

| Group | 1 | | | 2 | | | 3 | | | p* |
|---|---|---|---|---|---|---|---|---|---|---|
| | FASG | | | SSG | | | FASGC | | | |
| Implant | Mean ± SD | Min | Max | Mean ± SD | Min | Max | Mean ± SD | Min | Max | |
| 4 | 3.00 ± 1.68 | 0.30 | 6.30 | 3.27 ± 1.09 | 1.00 | 5.00 | 2.01 ± 0.46 | 1.30 | 3.10 | 0.015† |
| 7 | 3.35 ± 1.28 | 1.20 | 5.10 | 3.79 ± 1.40 | 1.40 | 7.20 | 1.84 ± 1.04 | 0.50 | 4.00 | <0.001‡ |
| 9 | 2.79 ± 1.62 | 1.10 | 5.90 | 2.19 ± 0.73 | 0.90 | 3.70 | 2.77 ± 0.55 | 1.92 | 3.60 | 0.238 |
| 14 | 2.51 ± 1.33 | 0.80 | 5.40 | 2.23 ± 1.34 | 0.30 | 5.20 | 3.53 ± 1.28 | 1.08 | 6.10 | 0.024§ |

* P-values corresponding to between-group analysis.

† In the post-hoc tests, there was a statistically significant difference between groups 2 and 3 (p=0.016).

‡ In the post-hoc tests, there were statistically significant differences between groups 2 and 3 (p<0.001) and between groups 1 and 3 (p=0.005).

§ In the post-hoc tests, there was a statistically significant difference between groups 2 and 3 (p=0.025).

Regarding the 3D offset at the base, Table 2 provides the results by group and subgroup. In the analyses of the simple main effects, there was a statistically significant difference between groups for implants #4, #7, and #9 ($p<0.05$), but not for implant #14 ($p=0.122$). Post-hoc tests demonstrated a statistically significant difference between groups 2 and 3 for implant #4 ($p=0.014$) and #7 ($p<0.001$), with higher levels of deviation for group 2 compared to group 3. There was also a statistically significantly higher level of deviation for group 1 compared to group 2 for implant #9 ($p=0.011$). The within-group comparisons of 3D offset at the base between different implants demonstrated no statistically significant difference for group 1 ($p=0.503$). For group 2, there was a statistically significant difference between the implants ($p<0.001$). Post-hoc tests showed a statistically significant difference between implants #4 and #9 ($p<0.001$), #4 and #14 ($p=0.0079$), and #7 and #9 ($p=0.001$). For group 3, there was a statistically significant difference between the implants ($p=0.002$). Post-hoc tests showed a statistically significant difference between implants #7 and #14 ($p=0.005$).

*Table 2*. Results for the 3D offset at base (in mm; n=15 per group)

| Group | 1 | | | 2 | | | 3 | | | p* |
|---|---|---|---|---|---|---|---|---|---|---|
| | FASG | | | SSG | | | FASGC | | | |
| Implant | Mean ± SD | Min | Max | Mean ± SD | Min | Max | Mean ± SD | Min | Max | |
| 4 | 0.60 ± 0.23 | 0.30 | 1.08 | 0.66 ± 0.20 | 0.31 | 1.03 | 0.45 ± 0.15 | 0.21 | 0.76 | 0.015† |
| 7 | 0.66 ± 0.14 | 0.36 | 0.89 | 0.66 ± 0.22 | 0.33 | 1.18 | 0.37 ± 0.15 | 0.13 | 0.59 | <0.001‡ |
| 9 | 0.67 ± 0.19 | 0.35 | 0.93 | 0.43 ± 0.18 | 0.09 | 0.85 | 0.51 ± 0.13 | 0.31 | 0.72 | 0.001§ |
| 14 | 0.60 ± 0.26 | 0.20 | 1.21 | 0.46 ± 0.16 | 0.25 | 0.83 | 0.60 ± 0.19 | 0.29 | 1.10 | 0.122 |

* P-values corresponding to between-group analysis.

† In the post-hoc tests, there was a statistically significant difference between groups 2 and 3 (p=0.014).

‡ In the post-hoc tests, there were statistically significant differences between groups 2 and 3 (p<0.001) and between groups 1 and 3 (p<0.001).

§ In the post-hoc tests, there were statistically significant differences between groups 1 and 2 (p=0.001) and between groups 1 and 3 (p=0.038).

Table 3 shows the results for the 3D offset at the tip by group and subgroup. In the analyses of the simple main effects, there was a statistically significant difference between groups for implants #4, #7, and #9 (p<0.05), but not for implant #14 (p=0.106). Post-hoc tests demonstrated a statistically significant difference between groups 2 and 3 for implant #4 (p=0.015) and #7 (p<0.001), with higher levels of deviation for group 2 compared to group 3. There was also a statistically significantly higher level of deviation for group 1 compared to group 2 for implants #7 (p<0.001) and #9 (p=0.011). The within-group comparisons of 3D offset at the tip between different implants demonstrated no statistically significant difference in group 1 (p=0.377). For group 2, there was a statistically significant difference between the implants (p<0.001). Post-hoc tests showed a statistically significant difference between implants #4 and #9 (p<0.001) and #7 and #9 (p=0.001). For group 3, there was a statistically significant difference between the implants (p<0.001). Post-hoc tests showed a statistically significant difference between implants #4 and #14 (p=0.002), #7 and #9 (p<0.001), and #7 and #14 (p<0.001).

*Table 3*. Results for 3D offset at tip (in mm; n=15 per group)

| Group | 1 | | | 2 | | | 3 | | | p* |
|---|---|---|---|---|---|---|---|---|---|---|
| | FASG | | | SSG | | | FASGC | | | |
| Implant | Mean ± SD | Min | Max | Mean ± SD | Min | Max | Mean ± SD | Min | Max | |
| 4 | 1.06 ± 0.55 | 0.17 | 2.14 | 1.19 ± 0.38 | 0.52 | 1.81 | 0.77 ± 0.16 | 0.51 | 1.02 | 0.017† |
| 7 | 1.19 ± 0.33 | 0.48 | 1.66 | 1.29 ± 0.47 | 0.55 | 2.42 | 0.55 ± 0.29 | 0.11 | 1.15 | <0.001‡ |
| 9 | 1.11 ± 0.44 | 0.59 | 1.78 | 0.76 ± 0.28 | 0.31 | 1.39 | 0.94 ± 0.16 | 0.68 | 1.13 | 0.015§ |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 0.96 ± 0.44 | 0.46 | 1.83 | 0.81 ± 0.40 | 0.25 | 1.72 | 1.13 ± 0.35 | 0.62 | 1.76 | 0.106 |

* P-values corresponding to between-group analysis.

† In the post-hoc tests, there was a statistically significant difference between groups 2 and 3 (p=0.015).

‡ In the post-hoc tests, there were statistically significant differences between groups 2 and 3 (p<0.001) and between groups 1 and 3 (p<0.001).

§ In the post-hoc tests, there was a statistically significant difference between groups 1 and 2 (p=0.011).

In conclusion, all surgical guide designs presented satisfactory performance with clinically acceptable levels of implant deviation. Full-arch surgical guides with crossbars presented higher accuracy when two or more guided implants were placed. In single-edentulous spaces, the shortened-arch surgical guide presented higher accuracy. Further research on different patterns of partially edentulous ridges, different designs of surgical guides, and different implant designs should be investigated to provide more information for clinicians to design reliable surgical guides in a more cost-effective manner.

**Project completion date:** July, 2021

**Journal of Oral Implantology Manuscript Submission Date:** August, 2021

**Project expenses:** A total of $15,911.06 was expended on this project, including Straumann Instrumentation Kit for Guided Surgery, Straumann BLT Guided Surgery Kit, coDiagnostiX 9 Guide Fees, model fabrication fees, and professional editing service to review the draft manuscript.