



A Novel Digital Radiation-free Technique For Assessing the Accuracy of Guided Implant Placement

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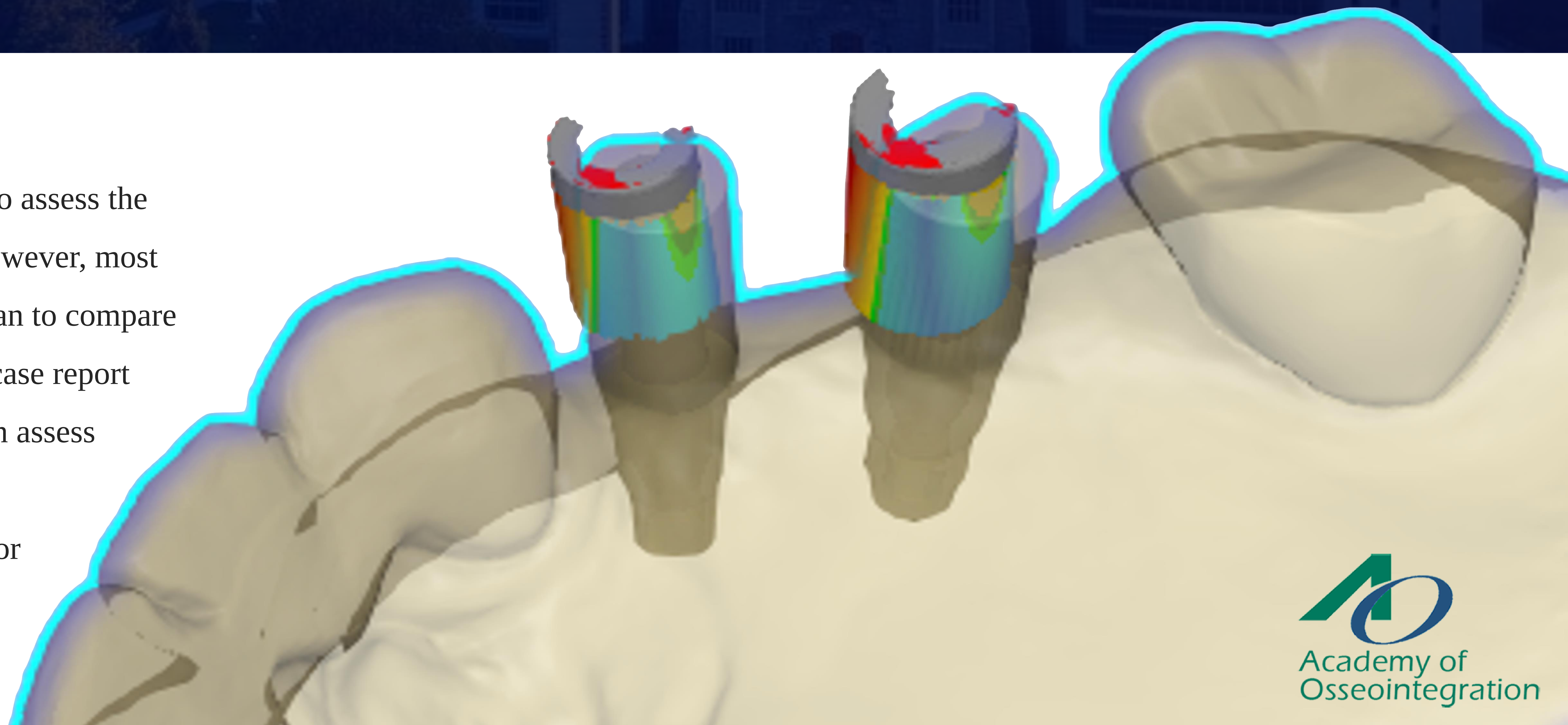
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Introduction

Several techniques have been introduced to assess the accuracy of guided implant placement. However, most of them require a post-operative CBCT scan to compare with the pre-operative implant plan. This case report describes a novel digital technique that can assess guided implant placement accuracy, using prosthetic components, without the need for additional radiation exposure after implant placement.





Methods

During digital planning of implants at sites #13, and #14, the implant scan bodies were exported along with the preoperative intraoral scan (IOS) of the maxillary arch using an implant planning software. A surgical guide was 3D-printed for fully guided implant placement in the stone model. Implant analogs were placed and then the scan bodies were tightened to them. The cast along with the scan bodies were scanned using IOS, and the STL file was exported into digital design software to measure the 3D-deviation between these scan bodies (representing the final implant position) to the reference scan bodies exported from the implant planning software. After the implants were placed intraorally and osseointegration, scan bodies were placed and IOS was recorded. The latter was also superimposed with the reference scan bodies position exported from the implant planning software.

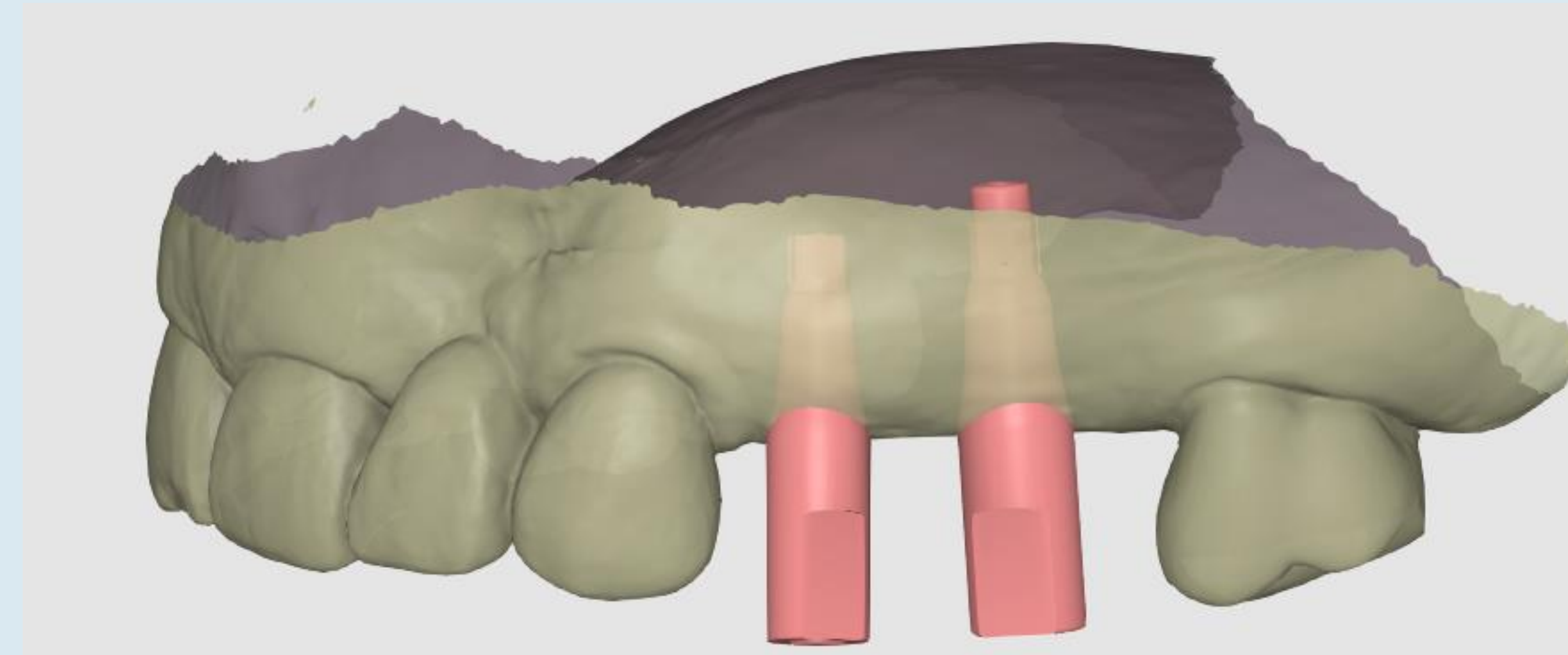


Figure 1: the implant scan bodies (reference scan bodies) were exported from an implant planning software



Figure 2: A 3D-printed surgical guide for fully guided implant placement in the stone model



Figure 3: Implant analogs were placed and then scan bodies were tightened to them followed by IOS

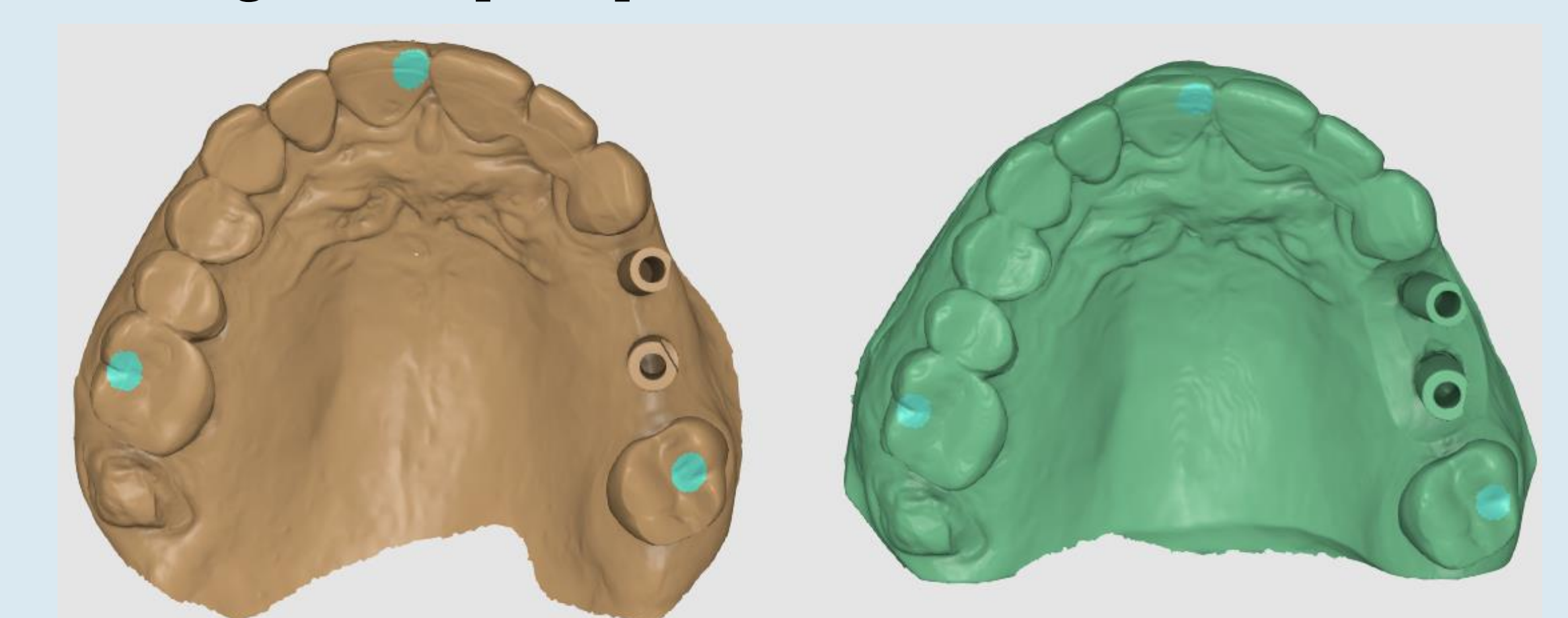


Figure 4: Three widely distributed areas for accurate alignment, while showing different orientation of the flat surface of the scan bodies

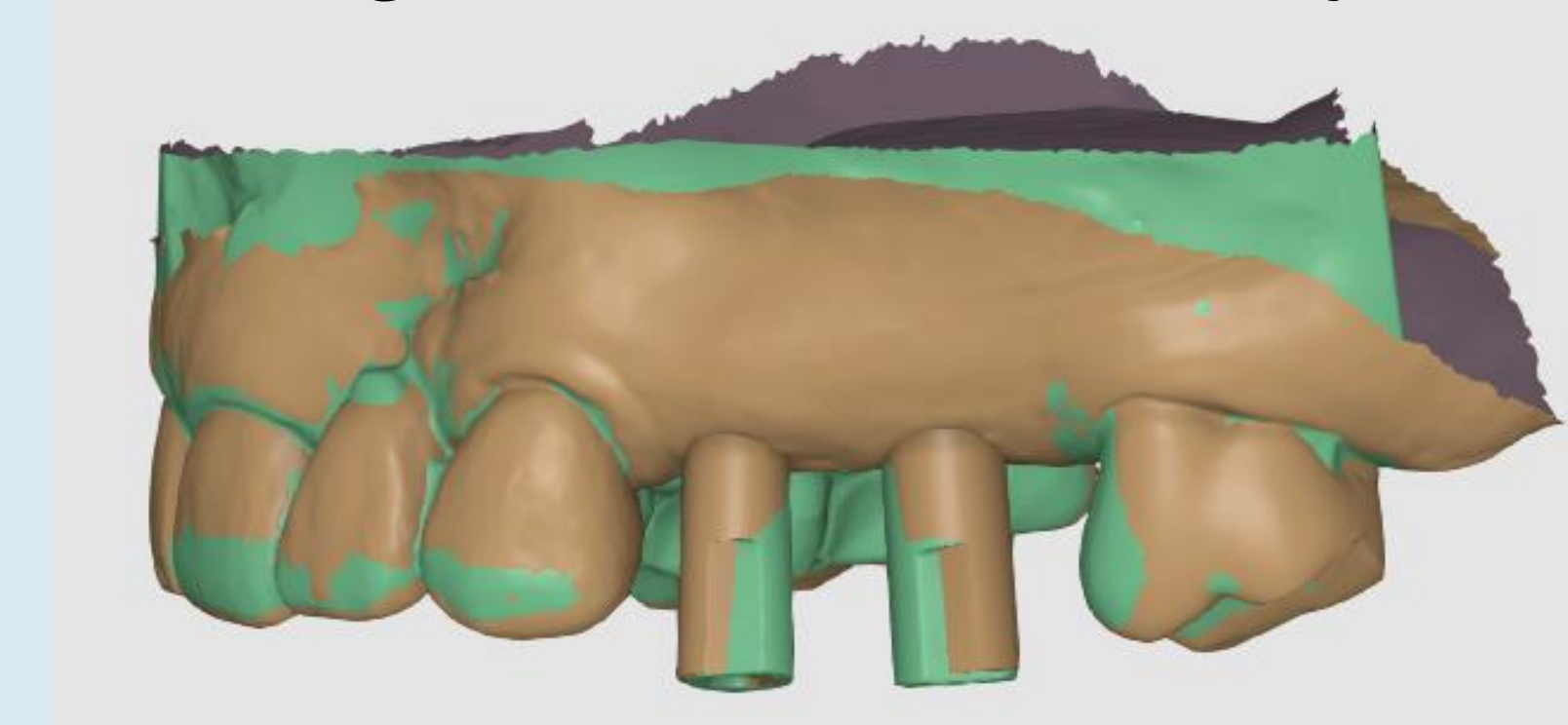


Figure 5: superimposed IOS with the scan bodies exported from the implant planning software used as reference

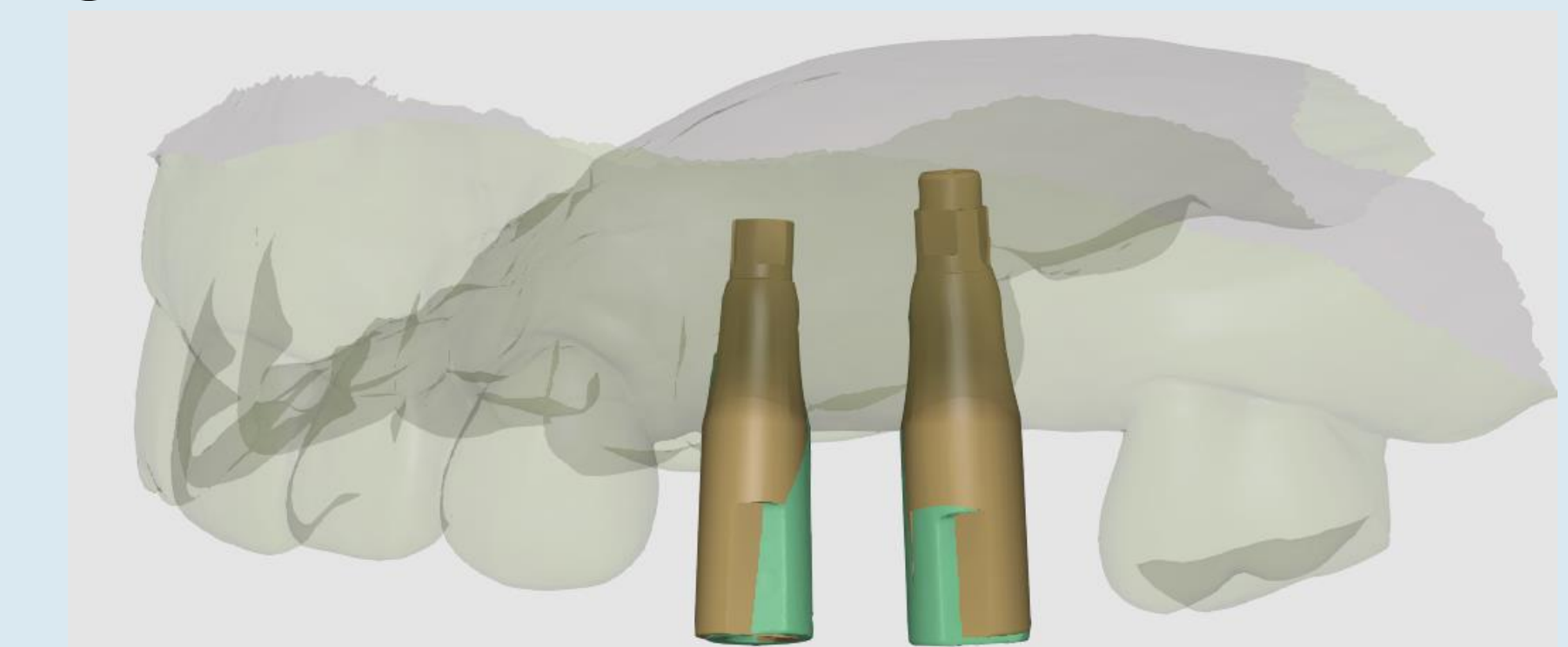


Figure 6: segmented scan bodies from their respective partially edentulous scans.



Results

The deviation between the implants in the model, represented by the scan bodies, showed an absolute mean of 0.194 ± 0.271 mm compared to the reference scan bodies (Table 1). Additionally, the vertical discrepancy between planning and execution of the implants, measured as linear deviation on the Y-axis, was 0.119 mm for #13 and 0.347 mm for #14.

3D-Deviation of implants position in the model (mm)	Scan bodies combined	Scan body #13	Scan body #14
Absolute mean $\pm$ standard deviation	0.194 ± 0.271	0.125 ± 0.177	0.286 ± 0.354
Root mean square	0.280	0.180	0.375

Table 1: Deviation between the implants placed in the model (fully guided) compared to the planned implants position (both represented by scan bodies)

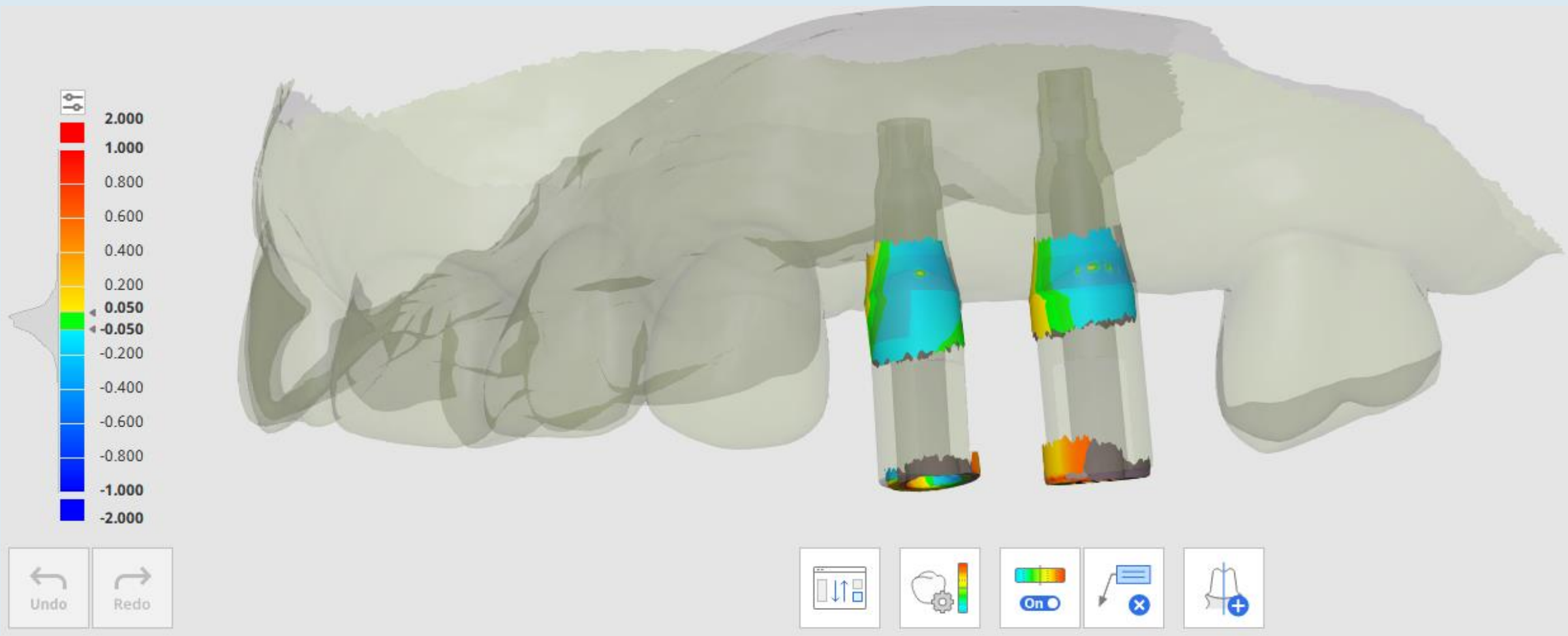


Figure 7: The segmented scan bodies with their flat surfaces removed leaving uniform geometry for precise measurement of 3D-Deviation

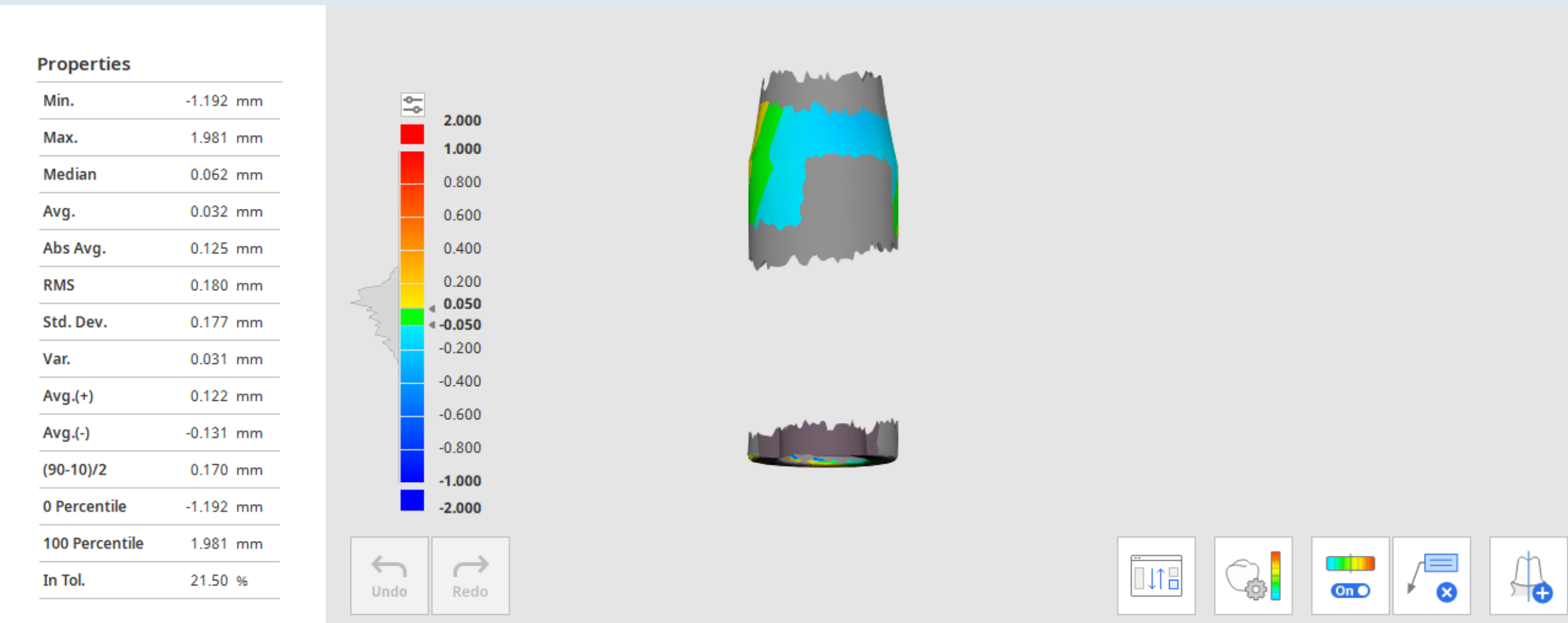


Figure 9: Each scan body was segmented separately. #13 implant had deviation of 0.463 ± 0.574 mm

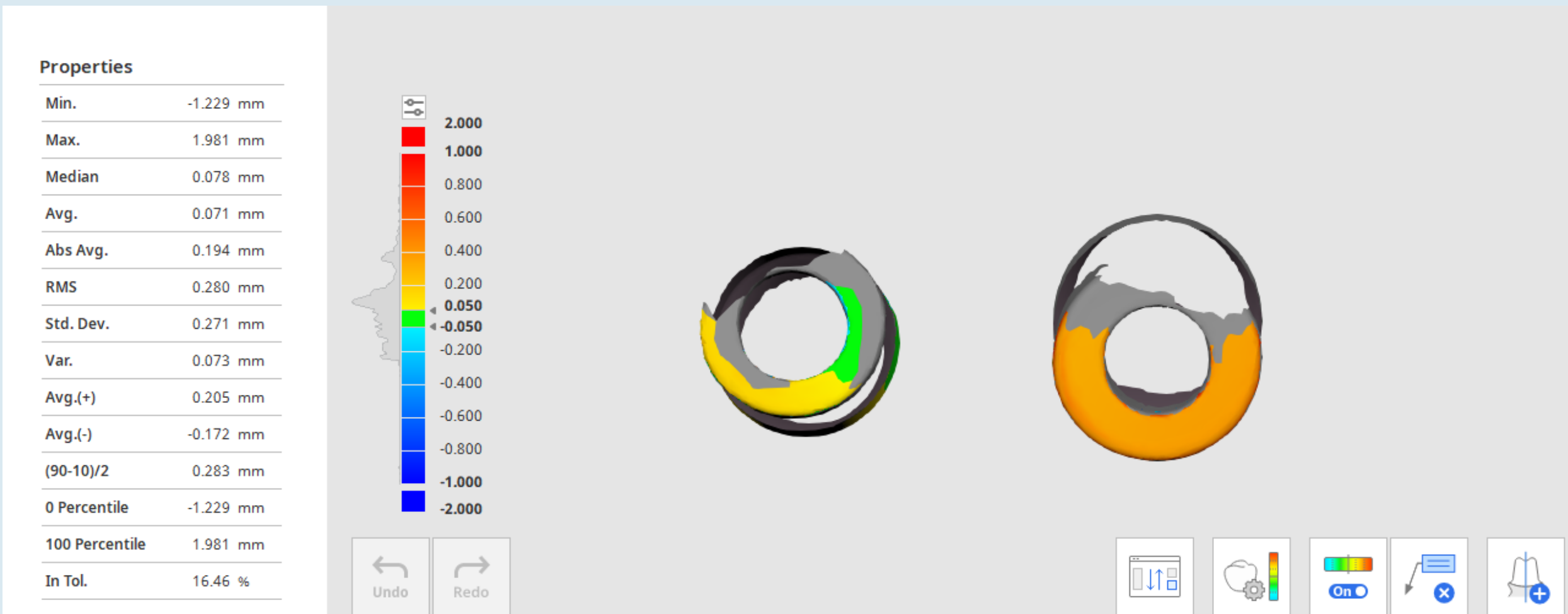


Figure 8: The 3D-deviation between the #13, and 14 implants position, represented by both scan bodies, had an absolute mean of 0.194 ± 0.271 mm

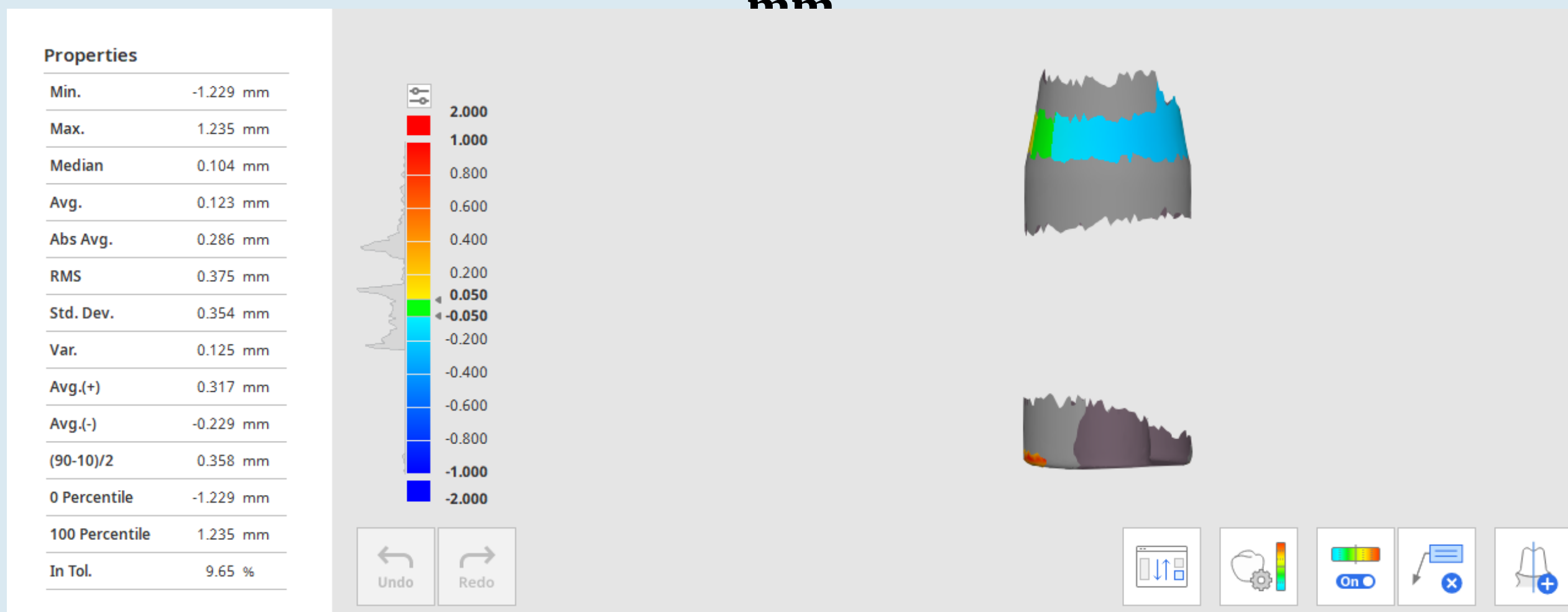


Figure 10: #14 showing deviation of 0.596 ± 0.745 mm

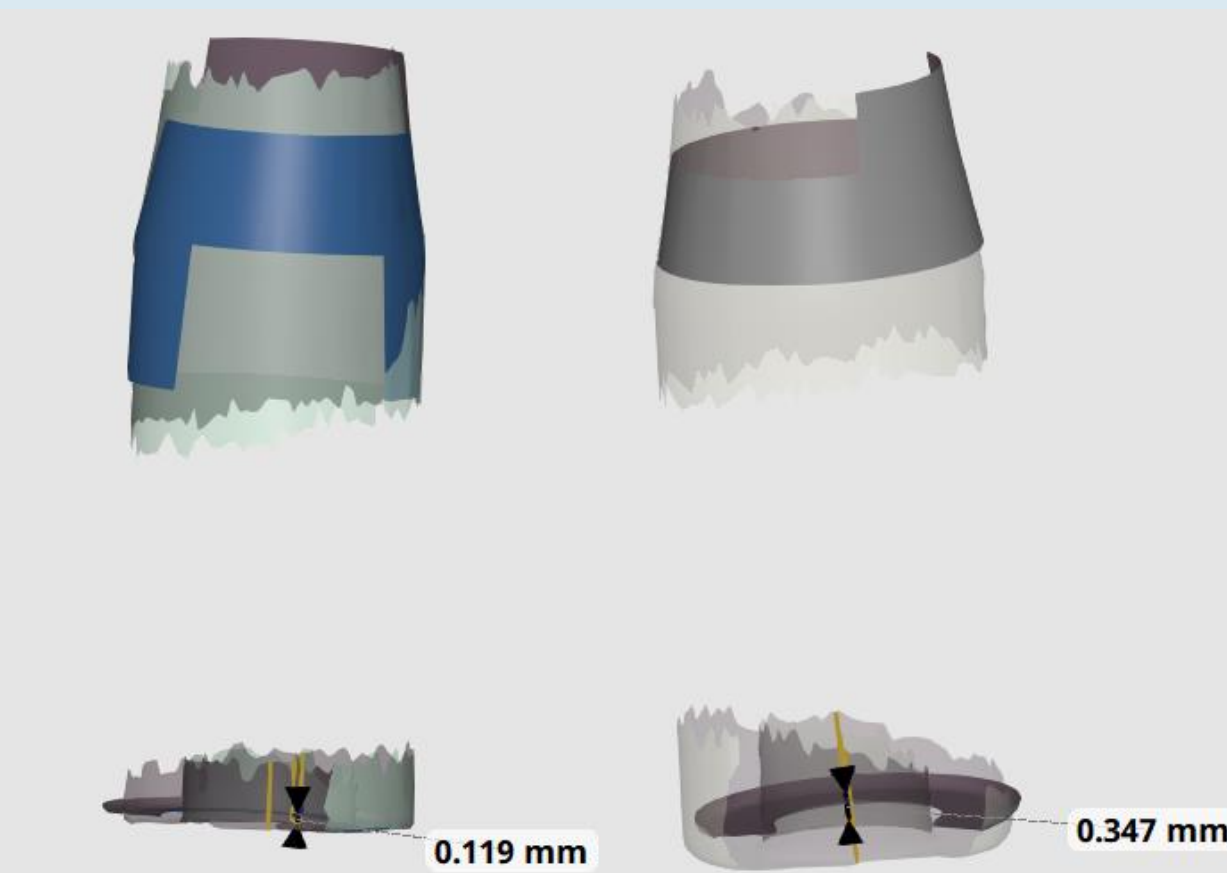


Figure 11: Vertical linear deviation of 0.119 mm for #13 and 0.347 mm for #14



Results

The deviation between the intraorally placed scan bodies and their reference scan bodies exported from the implant planning software (representing the planned implants position) had an absolute mean of 0.543 ± 0.682 mm as outlined in table 2.

3D-Deviation of intraoral implants position (mm)	Scan bodies combined	Scan body #13	Scan body #14
Absolute mean $\pm$ standard deviation	0.543 ± 0.682	0.463 ± 0.574	0.596 ± 0.745
Root mean square	0.727	0.630	0.785

Table 2: Deviation between the intraorally placed implants compared to the planned implants position (both represented by scan bodies)

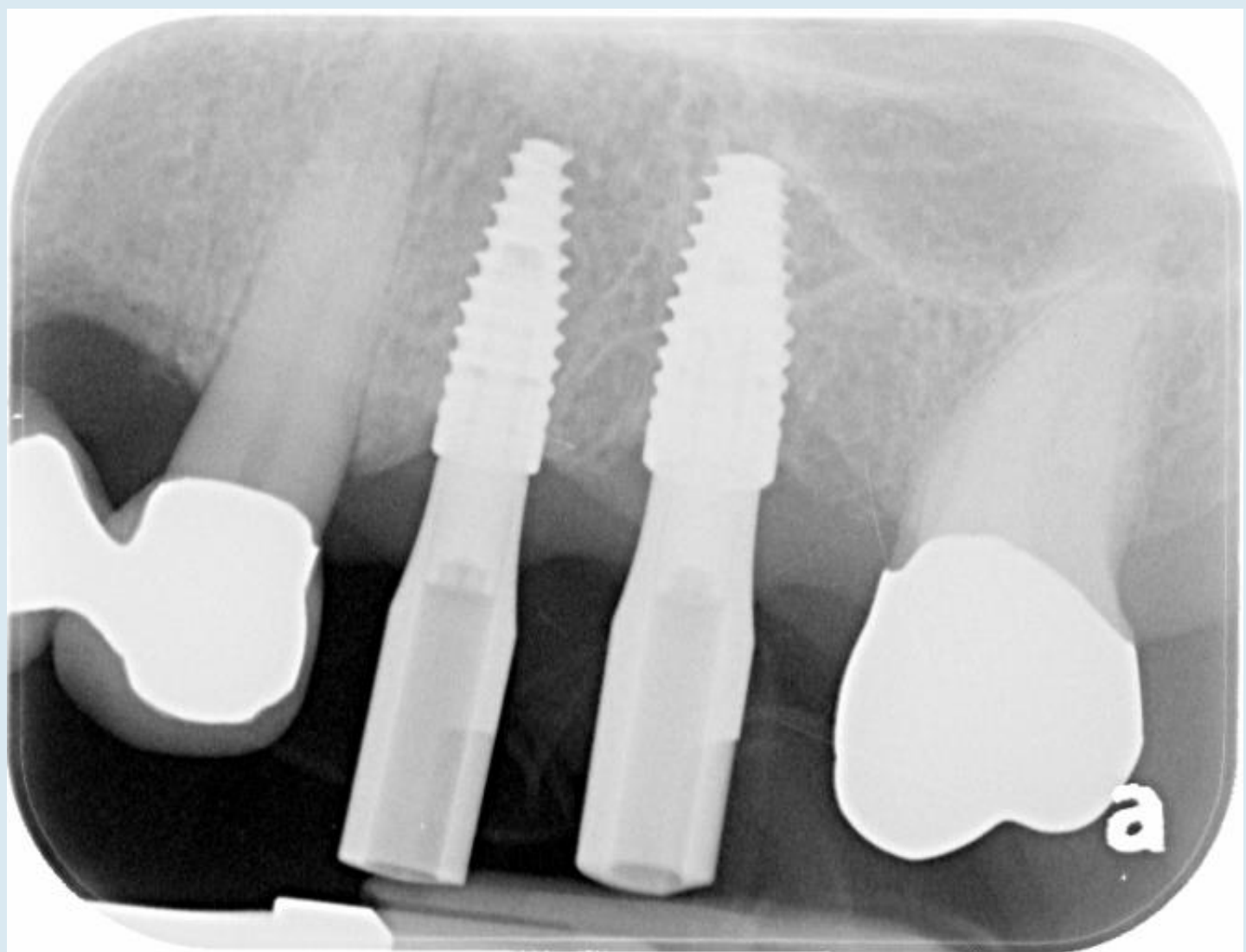


Figure 12: After implants placement and osseointegration, scan bodies were placed and IOS was recorded



Figure 13: The intraoral scan bodies were superimposed to the reference scan bodies followed by segmentation.

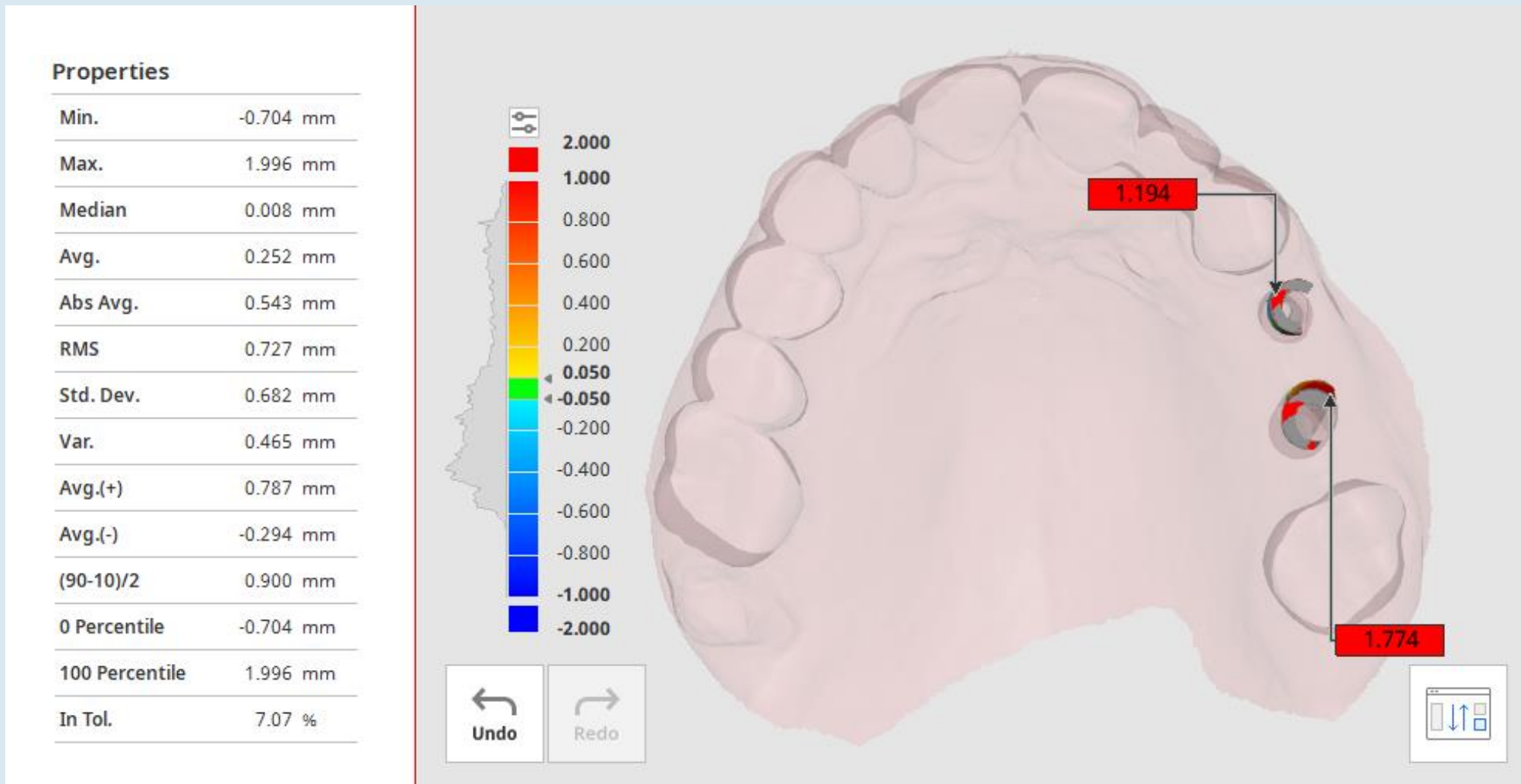


Figure 14: Deviation at #13, and 14 with absolute mean of 0.543 ± 0.682 mm

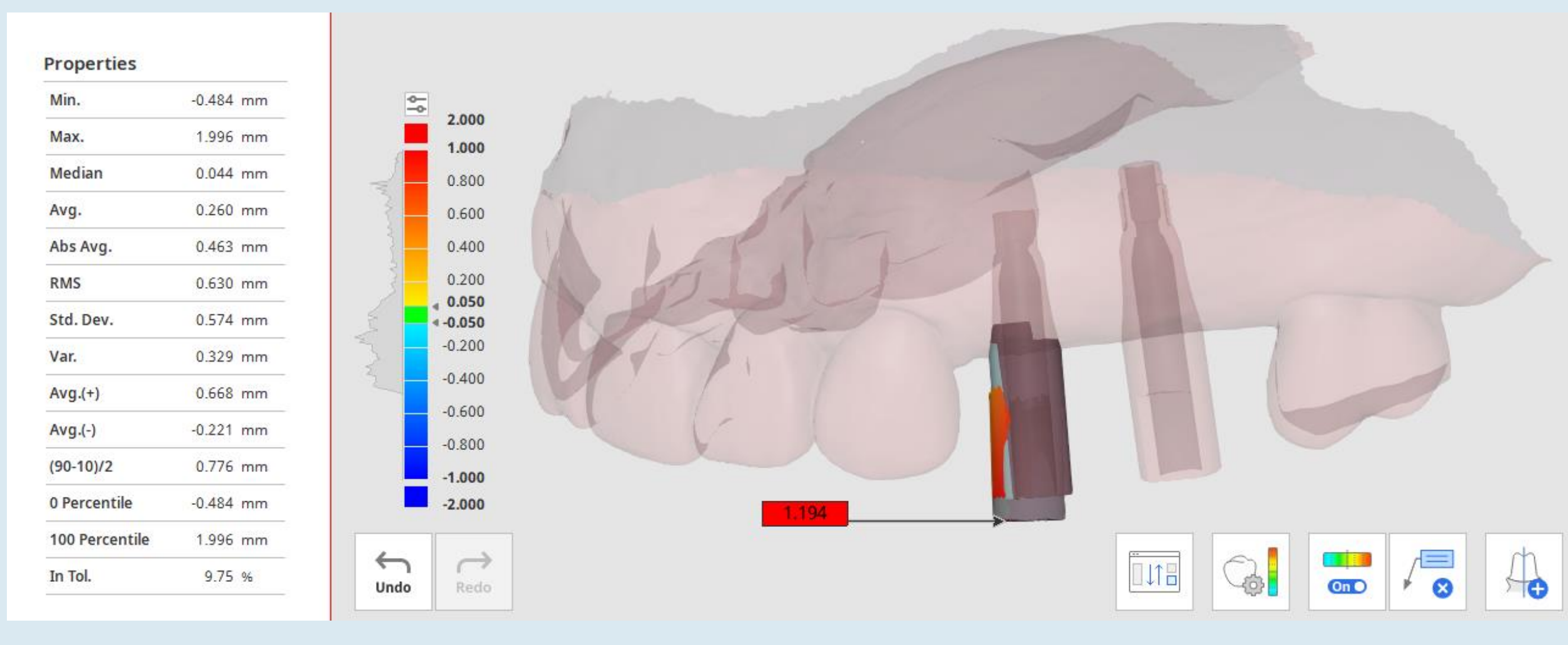


Figure 15: Each scan body was segmented separately. #13 implant had deviation of 0.463 ± 0.574 mm

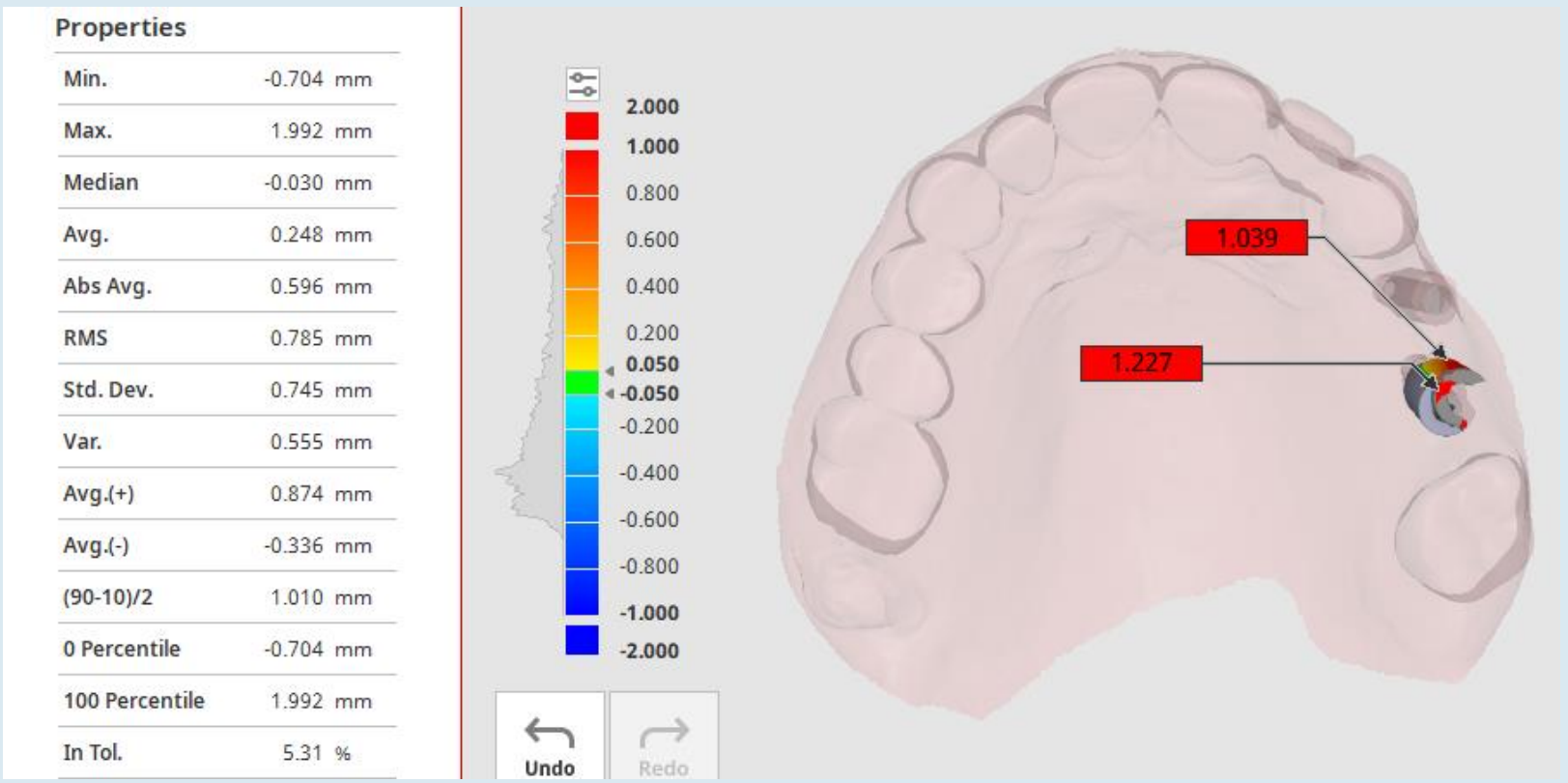


Figure 16: #14 implant showed deviation of 0.596 ± 0.745 mm



Conclusion

The suggested digital workflow can be applied on a model before implants placement or intraorally after osseointegration to assess the accuracy of guided implant placement without the need for exposing the patient to post operative CBCT. Furthermore, comparing scan bodies rather than implants for superimposition can facilitate conducting clinical trials without the need to scan the implant-scan body complex.

Future research

Comparing the accuracy of guided implant placement through aligning scan bodies, using the suggested workflow, to that analyzed from CBCT after implants placement (Figures 17 and 18) can be a subject of interest for future research.

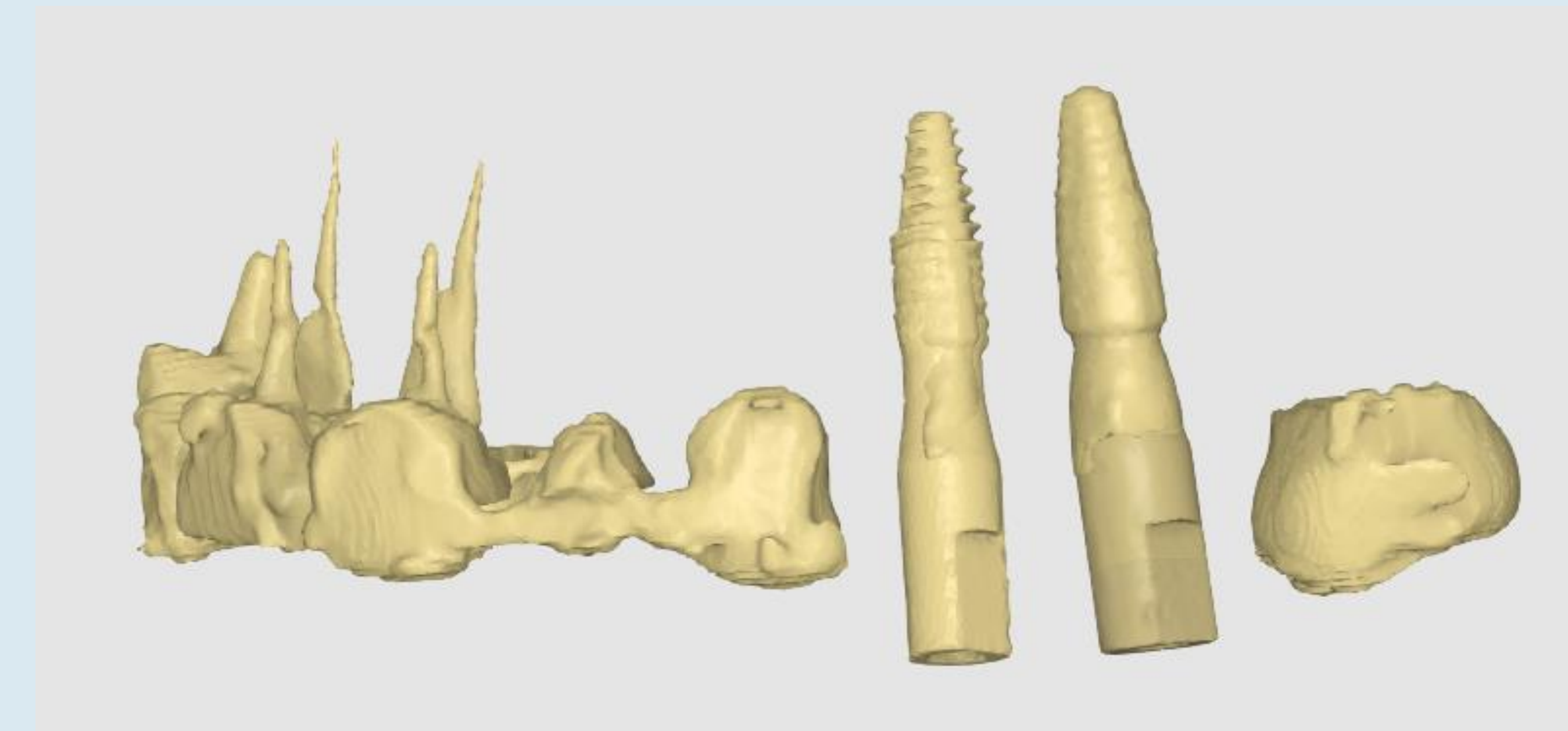


Figure 17: CBCT taken for implant planning in quadrant 1 showing segmented #13, and 14 implants

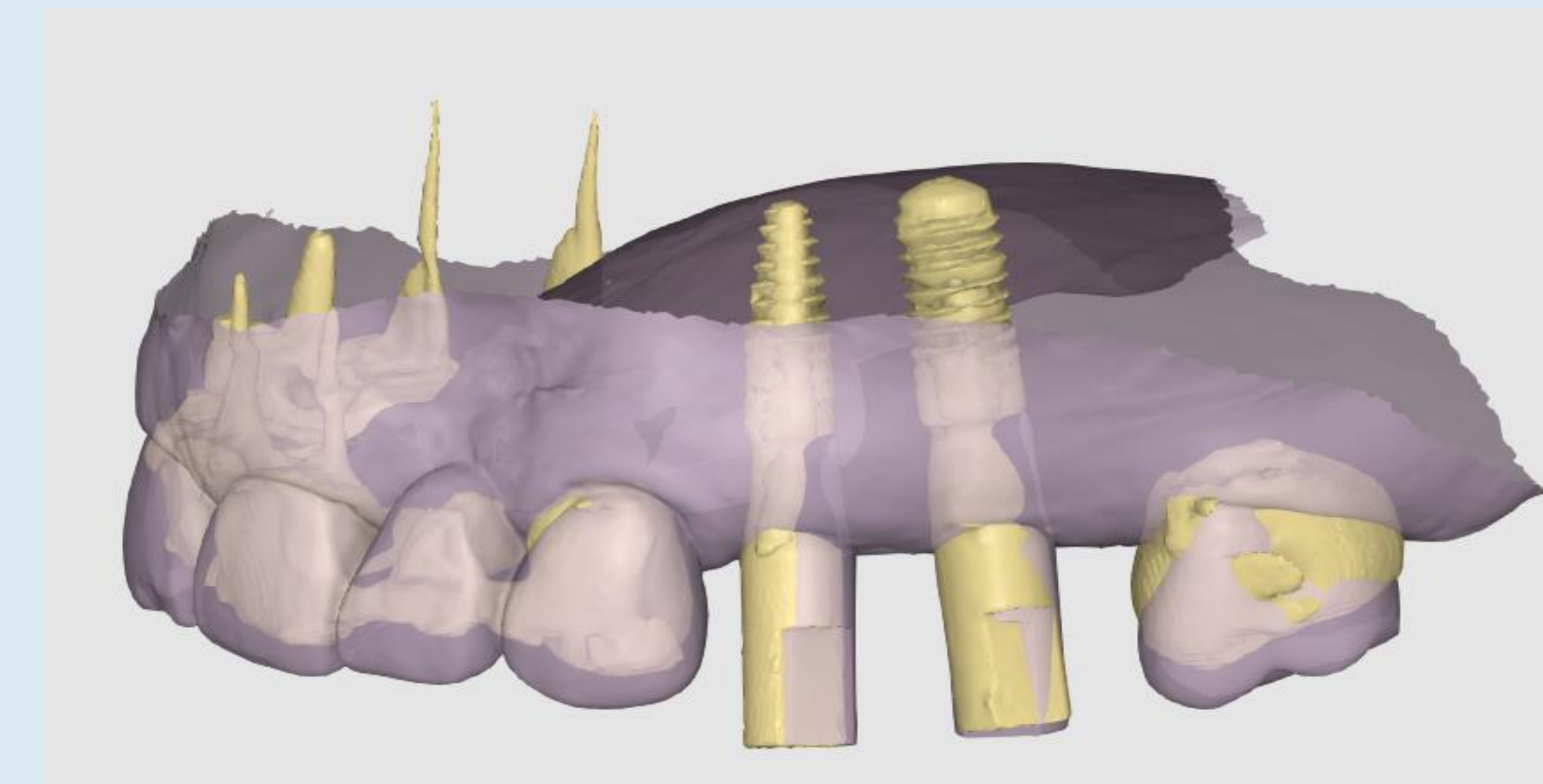


Figure 18: segmented implants position from the postoperative CBCT superimposed on the planned implants position exported from the implant planning software