

Comparative studies of the suitability and accuracy of DVTs and 3D scanners for model digitization

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Goals

Is it possible in practice to digitize plaster models using DVT instead of 3D scanners? What are the differences between the images produced by various 3D scanners and DVTs? Are 3D scanners more accurate than DVT devices?

Background

Devices for digitization of orthodontic models are increasingly in demand for digital planning, analyses and simplified archiving. Currently, around 10% of dental practices already own a DVT device.

Results

1.) Feasibility:

All DVT devices allow the digitization of models (Fig. 1). One manufacturer (Carestream) provides a corresponding tool for plaster models in its software.

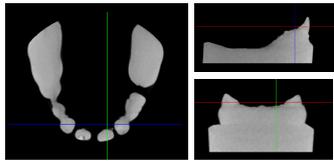


Fig. 1: Native layers of a model scanned in the DVT (Orange Green 3D). After scanning, the surface was segmented and stored as STL data.

2.) Accuracy differences between 3D scanners and DVTs:

There were only slight differences between the 3D scanners (mean ± SD: 0.017 ± 0.004 mm). There were qualitative differences between the DVT devices (Chi²=85.67, p<0.0001). The investigated Carestream device performed best and the eXam device worst (p<0.05, Fig. 3). The average deviations of the DVTs to 3D scanners were (mean ± SD): 0.064 ± 0.005 mm.

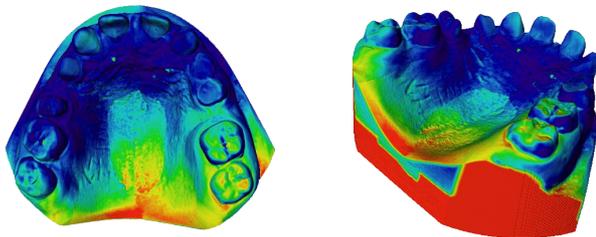


Fig. 2: Heatmap visualization of distances for a model digitized with Smart Optics Activity 300 and Orange Green 3D. Blue: 0 mm distance, Red: 1 mm distance.

Measurement deviations

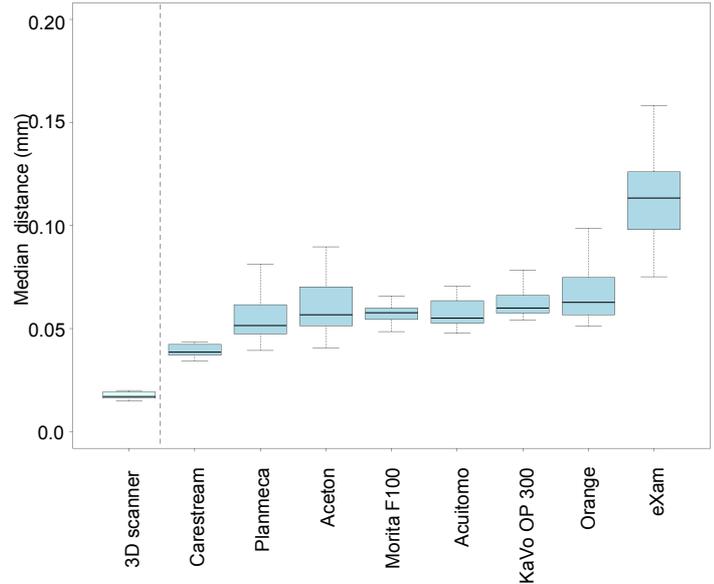


Fig. 3: Medians and quartiles for the scan deviations of 3D scanner (averaged) and DVT devices. The smallest deviation was shown by the Carestream device (p<0.05). The largest deviation was on the eXam device (p<0.05).

3.) Differences between 3D scanners and DVTs:

The paired t-test revealed significant differences between 3D scanners and DVTs (p<0.0001); the average distance was 0.046 mm.

Conclusions

- 1.) DVT devices are suitable in principle for the digitization of plaster models.
- 2.) The accuracy level of 3D scanners was not achieved by any of the investigated DVT devices; however, the deviation is relatively small (0.046 mm).
- 3.) There were greater differences in the scan accuracy between the DVT devices than between the 3D scanners.
- 4.) A DVT device with special software for plaster models performed best.
- 5.) Due to measurement deviations of <0.07 mm, digitization with DVT should play a subordinate role compared to 3D scanners for the long-term archiving of plaster models. However, each orthodontist should decide individually whether these deviations are acceptable.

Materials and methods

20 impressions were digitized from 10 patients using 5 different 3D scanners (3Shape D810, SmartOptics Activity 300, Dentaurum OrthoX, Imetric Iscan with HD cameras, Zirkonzahn S600) and 8 different DVTs (see Table 1) according to the respective manufacturer's recommendations.

The corresponding surfaces were recorded with Meshlab v1.3.4 and the median distance was calculated with Amira 6.1.1.

Therefore, every 3D or DVT scan was recorded 12 times with scans of other modalities. For statistical analysis, boxplots, a paired t-test, a Friedman's test and finally the post-hoc test Nemenyi test for pairwise comparison were used. The significance level was set at 5%.

Manufacturer, type:	kV:	mA (s)	FOV (cm ²)
Aceton, Whitefox	120	8	8 x 8
Carestream, CS 8100 3D	80	2	8 x 5
KaVo, OP300 3D	90	6.9	8 x 6
KaVo 3D eXam	120	37.07	8 x 8
Morita, Veraviewepocs 3D F100	80	3	8 x 8
Morita, Accuitomo	90	3	10 x 10
Orange Dental, Orange Green 3D	90	6	8 x 5
Planmeca, ProMax 3D Mid	80	12.5	10 x 10

Table 1: Investigated DVT devices and used scan parameters.