To Determine precision of a mounting jig routinely supplied alongside digital scanning equipment.

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INTRODUCTION

In dentistry occlusion simply means the contact between teeth, it is defined by the relationship between the maxillary and mandibular teeth. When the maxillary and mandibular teeth come together i.e. maximum meshing of the cusps of teeth, it is defined as ICP (intercuspal position) (Wassell et al., 2008.). In the ICP position the teeth apply maximum force (Ferreira et al., 2015). It is important to point out however, that ICP is a position determined by the teeth and as such is only a consistent and stable position if the individual has enough teeth to define it (Wassell et al., 2008.). The use of digital articulator in Prosthetic and Restorative dentistry can improve the design of dental appliances by incorporating kinematic analysis to the design procedure via CAD systems and reverse engineering tools (Koralakunte and Aljanakh, 2014). It offers the operator flexibility to adjust the patient settings i.e. enlarging jaw movements or restricting mouth opening, something that a normal articulator cannot offer (Koralakunte and Aljanakh, 2014). Therefore, dental appliances fabricated by digital articulators are more accurate (Solaberrieta et al., 2009.).

METHODS & MATERIAL

Eight final year dental students were selected to have impressions taken. Maxillary and Mandibular impressions were taken in medium-bodies silicon using stock trays.
The upper and lower cast were placed on the mounting jig, which was then inserted into the Solutionix Rexcan DS2 scanner. Solutionix Rexcan DS2 scanner scans the casts via optical scanning meaning that the casts are scanned in several angles and positions, the scans are then combined creating a 3D image on the screen.
The scan was then uploaded onto a software called Solutionix ezScan, where the scan was merged and aligned under high resolution. This was then saved as “01 Model – Upper” on a designated file. The process was then repeated for the lower cast and saved as “01 Model – Lower”. Both 01 casts were then mounted on the articulating jig and occluded to a stable ICP. Casts were again scanned, merged, aligned and saved as “01 Model – Occlusion A”. The casts and mounting jig was removed, taken apart and put back together again into a stable ICP. The process was repeated up to five times and scanned, giving a total of five occlusion scans labelled from A to E.

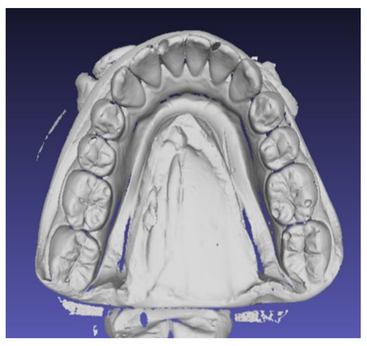

Fig. 1 Mandibular digital extra oral impression of participant 01 as viewed on Solutionix exScan.

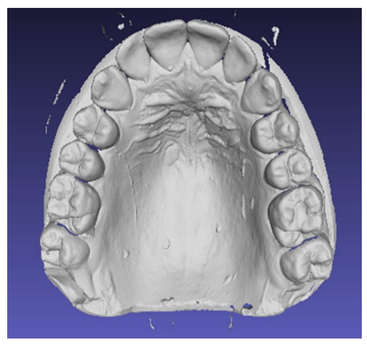

Fig. 2 Maxillary digital extra oral impression of participant 01 as viewed on Solutionix exScan.

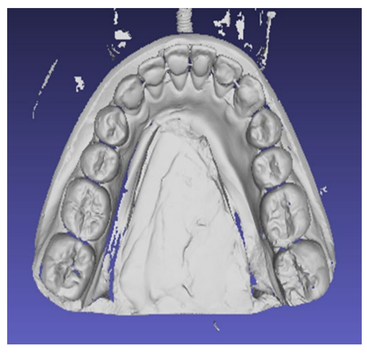

Fig. 3 Mandibular digital extra oral impression of participant 02 as viewed on Solutionix exScan.

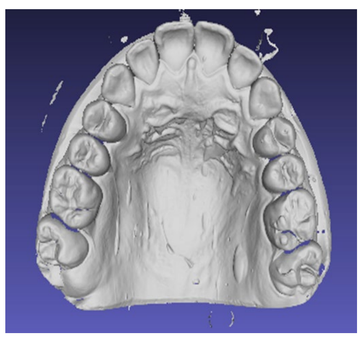

Fig. 4 Maxillary digital extra oral impression of participant 02 as viewed on Solutionix exScan.

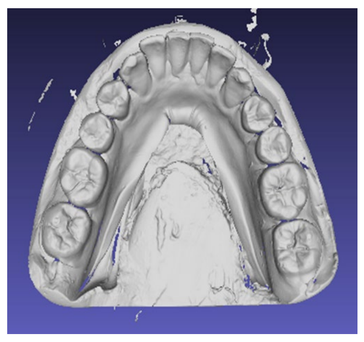

Fig. 5 Mandibular digital extra oral impression of participant 03 as viewed on Solutionix exScan.

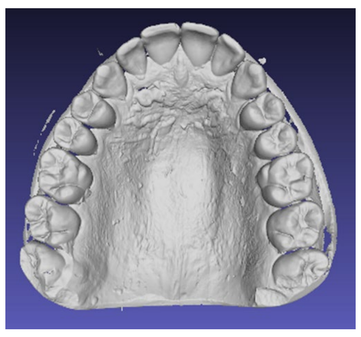

Fig. 6 Maxillary digital extra oral impression of participant 03 as viewed on Solutionix exScan.

Using MeshLab (Cignoni et al., 2008) all scans were inspected ensuring that all occlusal surfaces of models were scanned adequately giving us enough information with no missed surfaces that were important. The five scans for each pair of models were then aligned via custom software written by Leeds Digital Dentistry (Keeling and Osnes, 2020). The aligning gives us the best occlusion in the ICP position (Keeling and Osnes, 2020). Once all five occlusion scans of eight pairs of models were aligned, we had eight definitive pairs of aligned scanned.

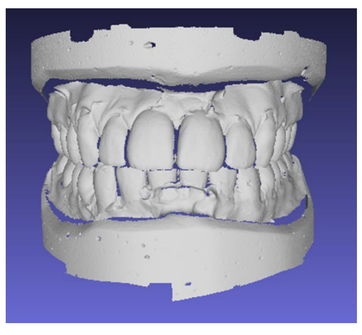

Fig. 7 Aligned scans of the occlusion of participant 02 using Custom Software by Leeds Digital Dentistry.

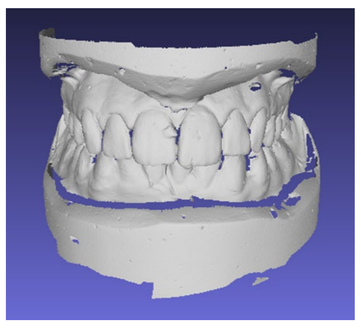

Fig. 8 Aligned scans of the occlusion of participant 04 using Custom Software by Leeds Digital Dentistry.

Starting from models 01 key point measurements were selected from three areas of upper and lower models. For the upper models, these were the mesial surface of the incisal edge of UR1 (first central incisor – right side), mesial palatal cusp on the UR6 (first molar – right side) and mesial palatal cusp on the UL6 (first molar – left side). For the lower three measurements were taken from the following mesial surface of the incisal edge of LR1 (first central incisor – right side), mesial lingual cusp on the LR6 (first molar – right side) and mesial lingual cusp on the LL6 (first molar – left side). Again, custom software written by Leeds Digital Dentistry was used. Because the scans are meshes which in turn are point clouds, the key point measurements that were taken are a single vertex point (vertices for plural) i.e. coordinates (Keeling and Osnes, 2020).

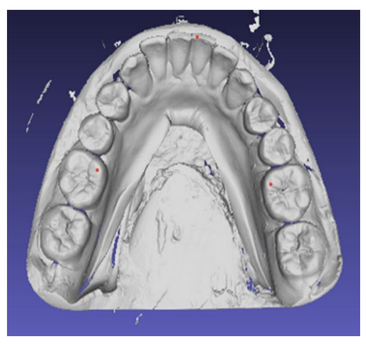

Fig. 9 Mandibular digital extra oral mesh of participant 03 showing key point measurements LR1, LR6 & LL6.

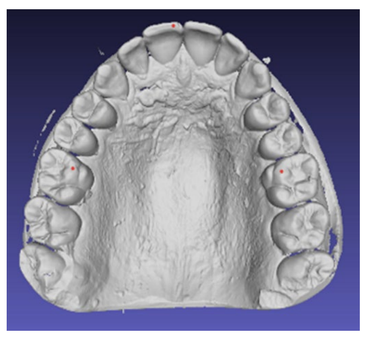

Fig. 10 Maxillary digital extra oral mesh of participant 03 showing key point measurements LR1, LR6 & LL6

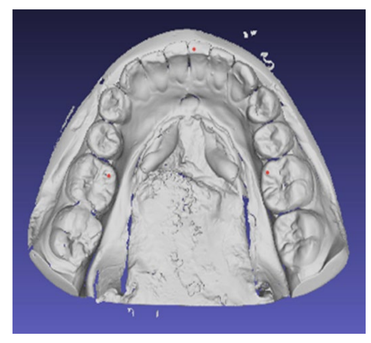

Fig. 11 Mandibular digital extra oral mesh of participant 04 showing key point measurements LR1, LR6 & LL6.

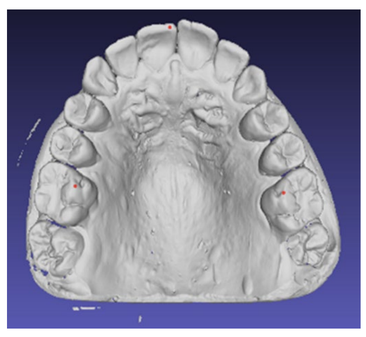

Fig. 12 Maxillary digital extra oral mesh of participant 04 showing key point measurements LR1, LR6 & LL6.

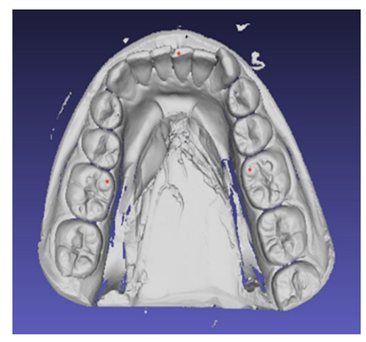

Fig. 13 Mandibular digital extra oral mesh of participant 05 showing key point measurements LR1, LR6 & LL6.

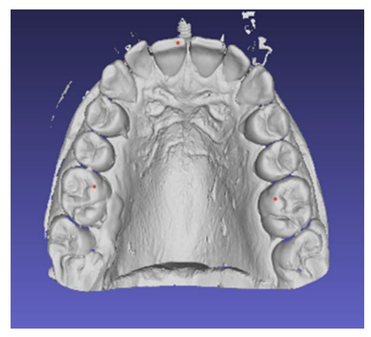

Fig. 14 Maxillary digital extra oral mesh of participant 05 showing key point measurements LR1, LR6 & LL6.

RESULTS

	UR1	UL6	UR6
Upper 01	1103273	365432	2014845
Upper 02	1237129	415692	2080550
Upper 03	1326345	476586	2232388
Upper 04	1444474	434922	2223890
Upper 05	1278555	425313	2085852
Upper 06	1415154	435855	2182489
Upper 07	1271261	416410	2051989
Upper 08	1261997	528820	1906964

Table. 1 Shows the vertex IDs identified on the upper mesh scans, selected from UR1, UL6, UR6

	LR1	LR6	LL6
Lower 01	923094	545602	2016591
Lower 02	932674	431749	1628741
Lower 03	1071651	481561	1782966
Lower 04	1148556	539334	1946694
Lower 05	1267871	590850	1910902
Lower 06	1395858	636968	2290565
Lower 07	1213413	530658	2002737
Lower 08	1202819	565106	1898070

Table. 2 Shows the vertex IDs identified on the lower mesh scans, selected from LR1, LR6, LL6.

	UR1 x	y	z	LR1						Distance	St dev
A	27.14	125.963	-181.834	26.4888	124.165	-179.581	0.6512	1.798	-2.253	**2.95514**	
B	25.5802	126.631	-182.789	25.522	124.283	-179.775	0.0582	2.348	-3.014	**3.82108**	
C	21.481	127.235	-179.334	21.4609	124.339	-176.618	0.0201	2.896	-2.716	**3.97037**	
D	21.6871	126.92	-180.578	21.6842	123.914	-177.918	0.0029	3.006	-2.66	**4.01393**	
E	21.6733	126.917	-180.653	21.6721	123.93	-177.978	0.0012	2.987	-2.675	**4.00971**	0.453443
	UL6			LL6							
A	3.09367	96.0965	-179.63	7.42604	98.9049	-180.018	-4.33237	-2.8084	0.388	**5.17756**	
B	2.69117	95.9351	-179.797	7.0186	98.6117	-180.303	-4.32743	-2.6766	0.506	**5.1134**	
C	0.0138701	95.4004	-178.412	4.26241	97.8635	-178.832	-4.24854	-2.4631	0.42	**4.92883**	
D	0.833758	94.6867	-179.442	4.99262	97.0962	-179.887	-4.15886	-2.4095	0.445	**4.82699**	
E	0.853784	94.6624	-179.502	5.01549	97.0903	-179.947	-4.16171	-2.4279	0.445	**4.83865**	0.160306
	UR6			LR6							
A	44.4407	93.2069	-179.759	40.9802	97.4841	-179.485	3.4605	-4.2772	-0.274	**5.50859**	
B	44.1091	94.5625	-180.579	40.5974	97.9273	-179.881	3.5117	-3.3648	-0.698	**4.91336**	
C	41.4309	95.9575	-179.915	37.8358	98.8699	-178.868	3.5951	-2.9124	-1.047	**4.74374**	
D	42.2213	96.0243	-181.236	38.5391	98.7566	-180.138	3.6822	-2.7323	-1.098	**4.71483**	
E	42.2406	96.0427	-181.281	38.5598	98.7939	-180.19	3.6808	-2.7512	-1.091	**4.7231**	0.338531

Table. 3 Shows x, y and z coordinates of the vertices in participant 01 using “Get Coordinate” programme, including distance calculated and standard deviation.

The vertex IDs were then imported into Microsoft excel. We then used the “get coordinate” programme which gave us the x, y and z coordinate of the vertices. Once we had the point location of the upper and lower point, we calculated the distance between these, by which the standard deviation arose from. The standard deviation is the variability of each key point between five different sets of scans (deviation in occlusion).

DISCUSSION

The study aimed to determine how precise the mounting jig is alongside digital scanning equipment. The findings show that the mounting jig is in effect close to accuracy, however they were some limitations that occurred. The standard deviation gives the reliability of the data, therefore, the smaller the standard deviation the more reliable the data and the larger the standard deviation the less reliable it is (Mullee, 2020). The findings show that the standard deviation achieved lies close to proximity meaning it is reliable. The study aim was to determine the precision of the mounting jig, how close it could get the two models to occlude in ICP. The standard deviation achieved is in millimetres i.e. that they discrepancies each time the models were scanned in an occluded position. The largest discrepancy was on participant 08 between the UR6 and LR6.

Currently there are no studies that compare the different types of 3D scanners due to an increasing amount of scanner types. To improve the study further an element of precision and trueness needs to be taken into consideration. Furthermore, to ensure the finding can have an impact it would be wise to compare the data against hand articulation using a similar method of marking the casts at three points this way it would then allow to assess if findings achieved are reliable or not.

Teaching in dental schools would also be changed, as this method of articulation (if more precise) could be incorporated into the curriculum agreed by Kumar et al. (2018) and Marti et al. (2017). Dental students would then need to be made aware of both methods of articulation and undertake training on using the software.

CONCLUSION

3D scanning is becoming increasingly popular due to patient demands within dentistry. The study aimed to determine the precision of the mounting jig routinely supplied alongside digital scanning machine. The data in hindsight indicates that the mounting jig is reliable in terms of creating occlusion, however, the sample is small for a conclusive result. Due to no comparable data, the study will need to be taken forward with the findings being compared to the traditional method for more reliable data, to ensure if the mounting jig is indeed precise enough to construct accurate occlusion.

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