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Accuracy of Different Interocclusal Recording Methods

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Abstract

Background: In order to fabricate successful prostheses, it is necessary to reproduce the interocclusal relationship accurately and transfer it to the articulator. This study evaluates the accuracy of different bite registration methods by comparing them with a standard model.

Methods: In this in vitro comparative analysis which was done in Duhok, Kurdistan Region, Iraq during 2023. Fully dentate upper and lower casts were mounted on an articulator. Different reference points were marked and the distances between upper and lower reference points with the occlusal plane angles were recorded using a measurement application. They were divided as anteroposterior left and right, buccolingual left and right, horizontal angles, and frontal angles. The lower second premolars and first molars were removed and the casts were duplicated and inter arch relations were transferred using dental wax, condensation silicone, additional silicone and the intra oral scanner. Each of the casts were specific to a single group with 10 samples each group. The measurements and angles were compared with the control group's measurements.

Results: The dental wax and the a-silicone showed significant recordable differences in anteroposterior and buccolingual, right and left ($P<0.05$). The condensation silicone was significantly different in anteroposterior right and buccolingual right ($P<0.05$) while the intraoral scanner was significantly different in anteroposterior and frontal readings ($P<0.05$). All the rest of the results provided no significantly recordable changes or differences($P>0.05$). The intraoral scanner showed the least mean difference while group A showed the most.

Conclusion: The results showed that all the mentioned methods had some discrepancies and differences. The intra oral scanner and the condensation silicone provided greater accuracy while the dental wax had the least.

Keywords: Dental Prosthesis, Dimethylpolysiloxanes, Jaw relation record, Vinyl Polysiloxane

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Introduction

In order to fabricate successful prostheses, it is necessary to reproduce the interocclusal relationship accurately and transfer it to the articulator. Previous research evaluated the accuracy of these processes and reported that mistakes have to be minimized during the bite registration procedure to reproduce the correct interocclusal relationship on the articulator. The factors that may cause additional errors during the bite registration procedure consists of anatomical complexities, physiological factors, and material properties.[1]Although its inherent nature constitutes a chance for error, the dental wax achieved broad acceptance for this specific transfer. Even with this being a versatile material, it is far from an ideal medium for the registration of the necessary interocclusal record.[2] Silicon-based impressions are now regarded as the material of choice for most clinical situations, and mainly for 'teeth-together' centric occlusion records. They are accurate, dimensionally stable, show minimal resistance to mandibular closure, and do not require a carrier vehicle.[3] There are two kinds of silicon-based material: condensation silicon and addition silicon. The latter has greater accuracy and greater dimensional stability.[4] In recent years, new elastomeric impression materials with very high elastic recovery and high tear strength have been used.[5] Impressions using an intra oral scanner only require a new acquisition of vestibular faces when the patient is in occlusion. Maxillary and mandibular arches are then aligned with a matching process. Even if this complicated algorithm requires coincident areas located under different planes, recent research stated that only one left and one right lateral occlusal record are required for software program alignment with a minimal dimension of 12 × 15mm.[6] The centric occlusal record is a 'tooth-together' record of the position of most intercuspation and is used for mounting preoperative and master models when no change in the current centric occlusion is proposed. Centric occlusion (CO) is by far the most frequently taken occlusal record in standard dental practice.[3] This study aims to evaluate and compare the accuracy of different bite registration methods including dental wax, condensation silicone (heavy body putty), bite registration auto mix system (addition silicone), and the intra oral scanner.

Material and methods

In this in vitro comparative analysis; which was done in Duhok, Kurdistan Region, Iraq during 2023; a fully dentate of maxillary and mandibular model (D95SFE-200(GUB)-MF, Nissen, Tokyo, Japan) was duplicated to create stone casts to be used as a simulation for the patient's mouth (Elite rock, Zhermack, Badia Polesine, Italy). Mounted on a semi-adjustable articulator (A7 plus, Bio-art, Sao Paolo, Brazil), the casts were adjusted using articulating papers and diamond burs until a baseline occlusal relationship was established. The following points were marked on the first premolars which will hold the cast in a stable relationship: A- The summit points of the tip of the buccal cusps of upper right first premolar, upper left first premolar.[7] B- The summit points of the tip of the buccal cusps of lower right first premolar, and lower left first premolar. C- The point in the centre of the buccal maximum convexity of upper right first premolar and upper left first premolar. D- The summit points of the tip of the lingual cusps of lower right first premolar and lower left first premolar. E- The most incisal point of the inter dental papilla between the upper right central incisor and upper left central incisor. F- The most incisal point of the inter dental papilla between the lower right central incisor, and lower left central incisor, Figure (1).

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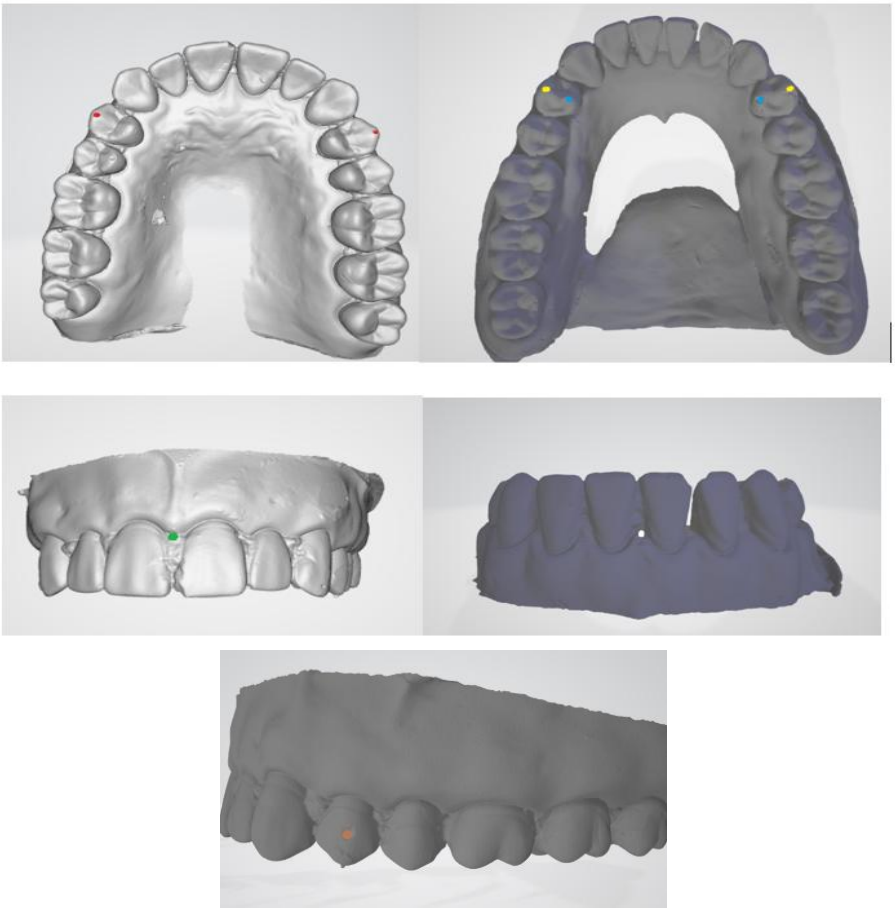

Figure (1): showing the designated points: Points A in red, B in yellow, C in brown, D in blue, E in green and F in white

Dental pins were carefully inserted using low speed handpiece at these points to prevent any prospective confusion. The casts were scanned (T710, Medit, Seoul, Korea) and a measurement application (Medit design v2.1.2, Korea) was used to measure the following: (1) An imaginary line between points (B) and passes through points (A) and (C) while being perpendicular to it. This line represented the baseline record for the anteroposterior plane, Referred to as the AP line Figure (2A). (2) An imaginary line between points (D) and passes through points (A) and (C) while being perpendicular to it. This line represented the baseline record for the buccolingual plane. (Referred to as the BL line Figure (2B). (3) The points in (A) were connected with the point in (E). The triangular result represented the maxillary plane. In the same way, the points in (B) were connected with the point in (F) and produced the triangular representation for the mandibular plane Figure (3). (4) The angle created by the maxillary plane relative to the mandibular plane was calculated on the horizontal and frontal planes for baseline records. A positive angle was recorded when the maxillary plane deviated to a counterclockwise direction in the horizontal plane when seen from above (Referred to as the H angle) and when the maxillary plane on the left aspect was upright in the frontal plane when seen from the front (Referred to as the F angle) in the same way mentioned by Iwaki et al.[8]

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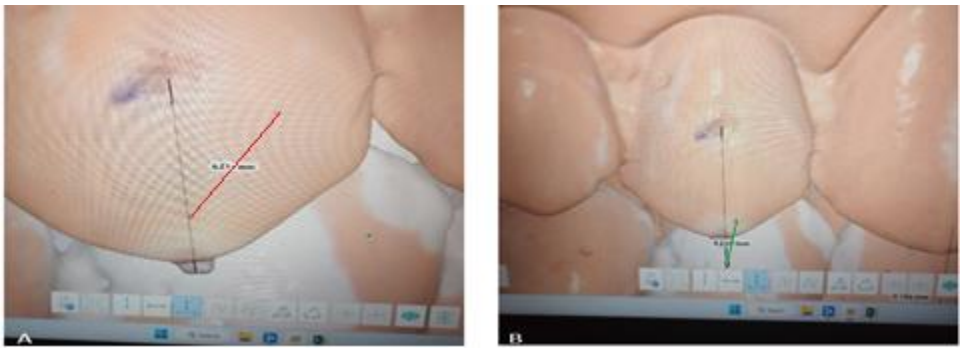
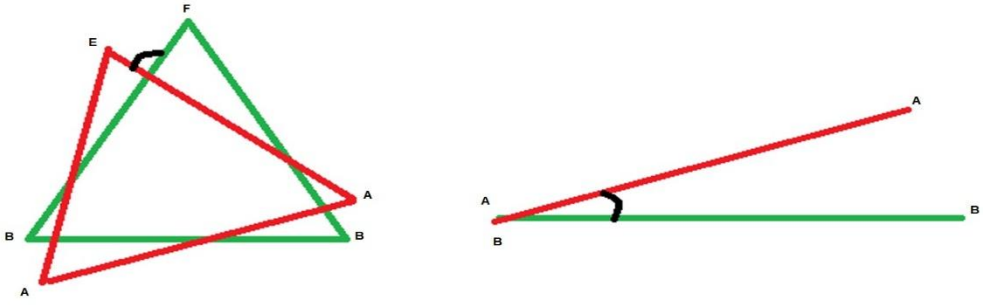


Figure (2): showing the AP line (in red) and the BL line (in green) with the method of recording.



A B

Figure (3): Joining the points on the left and right buccal cusps and on the anterior point will create a triangle. The maxillary and the mandibular triangle will create an angle when viewed from the (A) horizontal and (B) frontal views.

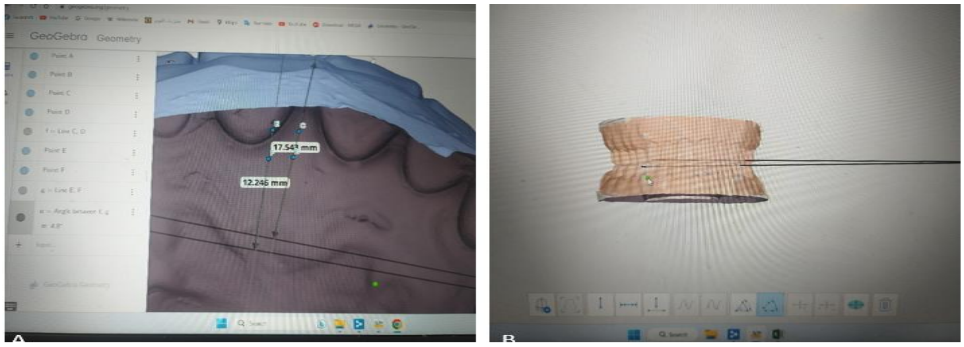


Figure (4): Calculating the angles created by the planes in Figure (2) in the baseline casts.

The measurements were repeated three times by a single examiner (H. A.), and the mean distances were recorded, Figure (4). After standardization and creating baselines, the following teeth were removed: lower right second premolar, lower left second premolar, lower right first molar and lower left first molar. This step was to simulate loss of teeth or preparations. The upper and lower casts were duplicated 40 times by custom-trays

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with using a-silicone and the produced upper and lower casts were randomly divided between the following groups according to the four methods used for testing: Group A: Dental wax (N 10). Wax sheets (Polywax, Bilkim, Izmir, Turkiye) were halved. Each half was placed in a warm water bath for one minute. The plate was removed, folded and placed on the lower teeth, and the articulator was closed. Any excess material was trimmed. Then the wax sheet was carefully removed, washed by cold water, and placed on the occlusal surface of the assigned casts which were mounted immediately. Group B: Condensation silicon putty (N 10). A supply provided by the manufacturer (Zetapuls, Zhermack, Badia Polesine, Italy) where a spoon sized putty was mixed by the activator for 30 seconds and put evenly on the occlusal surfaces of the lower teeth. Then the upper teeth were occluded on the lower teeth and the material was allowed to set for four minutes and forty-five seconds. The registration was removed from the articulator and any excess material was trimmed and placed on the occlusal surface of the assigned casts which were mounted immediately. Group C: Polyvinyl silicon bite registration (N 10). The cartilage (o-bite, DMG, Hamburg, Germany) was inserted in the auto-mix dispenser and the material was applied evenly on the occlusal surfaces of the lower teeth. Then the upper teeth were occluded and the material was allowed to set for one minute and thirty seconds. The registration was removed from the articulator and placed on the occlusal surface of the assigned casts which were mounted immediately. Group D: Intra oral scan (N 10). IO camera (Trios 3, 3shape, Copenhagen, Denmark) was used to scan the casts. The resulted files were sent to the research lab to calculate measurements, Figure (5).

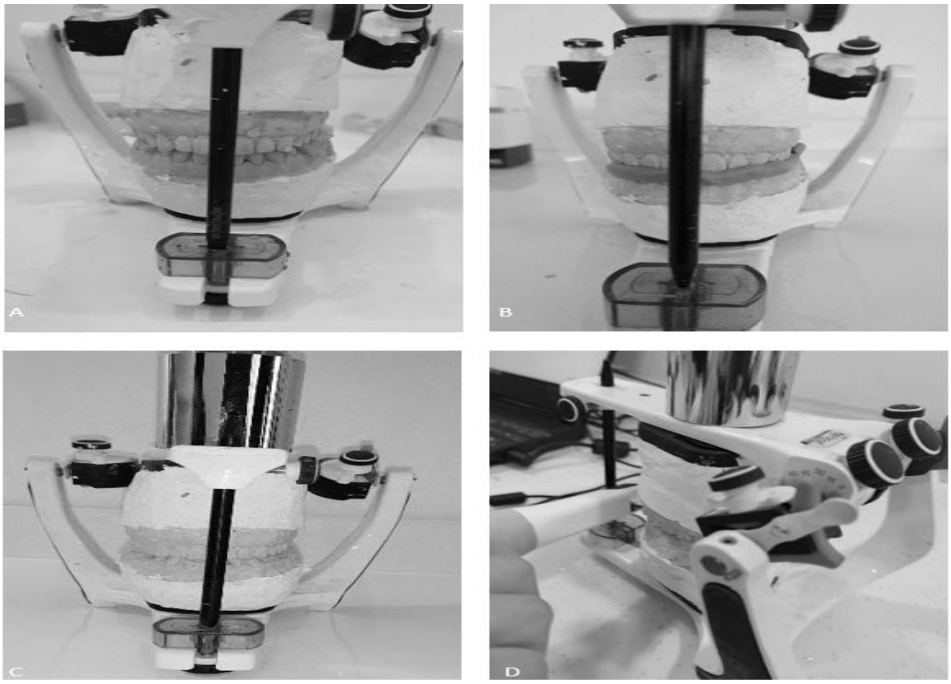

Figure (5): Registering the occlusion between the baseline casts using, (A) dental wax, (B) c-silicone heavy body and (C) a-silicone bite registration material, (D) Intra oral scanner

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Every group had 10 casts and the sum was 40 upper and lower casts. For the purposes of standardization, a 1 Kg (9.81N) metal was placed on the articulator to simulate the occlusal force. The recorded measurements of the (AP) line, (BL) line were by millimeters, and the (H) and (F) angles were by degrees. These were then analyzed by the same method that used for the control casts and then compared with the baseline readings. For statistical analysis; we used IBM SPSS Ver 25. Normality distribution was tested for each group using the Kolmogorov-Smirnov test. Based on the results, a paired t-test was used for normally distributed data, and a one-sample Wilcoxon signed rank test was used for non-normally distributed data. Pair-wise comparisons were made between each technique and the control measurement, which was considered as a test value. The assumptions for each test were checked and met. A *p*-value of ≤ 0.05 was considered significant.

Results

In Table (1); For (AP) left, groups A, C, and D showed significant changes. while group B did not. For (AP) right, all groups showed a significant change. For (BL) left, groups A and C, showed a variance of (P<0.05). while groups B and D showed no significant change. For (BL) right, groups A, B and C showed a variance of (P<0.05) while group D had no significant change. For the (H) angle, all groups showed insignificant variance while group A mean provided the closest value to the baseline reading. And in the case of (F) angle, only group D showed significant change. Both group A and B gave the closest values to the baseline reading.

Table (1): t-test results of the study groups compared with the baseline

		Baseline	Group A	Group B	Group C	Group D
AP left	Mean	3.883	3.2837	3.7925	3.4693	4.0054
	SD		0.60226	0.24598	0.22191	0.11014
	P-value		0.12	0.93	0.93	0.007
AP right	Mean	5.41	4.9551	4.9155	5.0477	5.2886
	SD		0.44569	0.22349	0.32202	0.15369
	P-value		0.007	0.00	0.006	0.034
BL left	Mean	7.175	6.3761	6.9704	6.6592	7.1569
	SD		0.3045	0.33679	0.3682	0.11971
	P-value		0.000	0.087	0.002	0.644
BL right	Mean	7.418	6.8956	7.1384	6.9389	7.4762
	SD		0.38357	0.24225	0.53687	0.11228
	P-value		0.002	0.005	0.02	0.136
H angle	Mean	-1.4	-0.29	-3.063	-3.925	1.12
	SD		4.90475	3.31269	3.87537	5.44728
	P-value		0.492	0.147	0.069	0.314
F angle	Mean	-1.3	-1.21	-1.22	-0.92	-0.94
	SD		0.30714	0.38528	1.14969	0.3134
	P-value		0.256	0.372	0.323	0.005

Table (2) shows the absolute mean differences of the baseline readings for each group. By examining the (AP) left's column, it shows that group C gave numerically the lowest result and group A gave the highest result. All the mean values obtained are within the limits of confidence interval. The smallest difference recorded was in group D (0.127mm) and the largest mean difference was recorded in group A (0.864 mm). The

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order of the mean difference from the baseline readings, from the smallest to the largest, was as follows: group B, group D, group C, and group A. By examining the (AP) right's column, it shows that group D gave numerically the lowest result and group C gave the highest result. All the mean values obtained are within the limits of the confidence interval. The smallest difference recorded was in group D (0.397 mm) and the largest mean difference was recorded in group B (0.254 mm). The order of the mean difference from the baseline readings is, from the smallest to the largest, as follows: group D, group C, group A, and group B. When the data of (BL) left's column are examined, it shows that group D gave numerically the lowest result and group A gave the highest result. Most of the mean values obtained are within the limits of the confidence interval. The smallest difference recorded was in group D (0.166mm) and the largest mean difference was recorded in group B (0.345 mm). The order of the mean difference from the baseline readings is, from the smallest to the largest, as follows: group D, group B, group C, and group A. When the data of (BL) right's column are examined, it is found that group D gave numerically the lowest result and group A gave the highest result. All the mean values obtained are within the limits of the confidence interval. The smallest difference recorded was in group D (0.159 mm) and the largest mean difference was recorded in group C (0.728 mm). The order of the mean difference from the baseline readings is, from the smallest to the largest, as follows: group D, group B, group C, and group A.

Table (2): The absolute differences of the means of the groups from the baseline

	AP Left	AP Right	BL Left	BL Right
Group A	0.5993	0.4549	0.7989	0.5224
Group B	0.0905	0.4945	0.2046	0.2796
Group C	0.4137	0.3625	0.5158	0.4791
Group D	0.1224	0.1214	0.181	0.0582

Discussion

This study aimed to evaluate the different bite registration methods by comparing the distances between upper and lower premolars and predefined angles on control casts and the same distances on copy casts. The null hypothesis was that there is no statistically significant difference between the bite registered by using the different material or method and the baseline records that was taken earlier on the standard cast. Mean differences were also taken for better understanding of the accuracy of each mentioned method. All tests were performed by a single researcher to minimize the potential for variability in the results. For the dental wax, the material was statistically significant in all the recorded distances. Additionally, it has the most value of mean differences from the baseline record. This is consistent with other research publications mentioning how dental wax is considered as the most inaccurate material among the interocclusal records studied.[9-11] Even though others have found that the dental wax had adequate records.[12] Further studies found that greater displacement could happen with thicker dental wax in all directions. It was reported that a roughly 2 mm space between any platform for interocclusal records and the opposite tooth was proposed for proper outcomes.[2] Still, it's more preferred because it can be easily and quickly modified through heat and changed multiple times to provide the desired outcome.[13] For the condensation silicone, the putty did not show a statistically

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significant difference in left side distances and in contrast to right-side distances of the baseline records. The mean differences of the condensation silicone were less than that of the addition silicone in most of the dimensions (3 out of 4), which goes against other research studies where they found that addition silicone had more dimensional stability and less deformity.[14] This is perhaps due to the fact that the dimensional change of the c-silicone can be minimized when the models are casted as soon as possible, which was performed during this research.[15] In case of the addition silicone, it showed a statistically significant difference with the standard measurements. This contradicts with what other researchers found showing polyvinyl siloxane materials resulted in accurate replication of the articulation because of its properties for dimensional stability and reproduction of anatomical details.[11,13,16] Some authors argue that elastomeric interocclusal materials are unsatisfactory because they may rebound after the setting of the cast onto the articulator.[13] When the intra-oral scanner was used for bite registration, it showed a statistically significant difference of the standard cast in anteroposterior measurements and an insignificant difference in the buccolingual measurements. Additionally, it had the smallest mean differences and the smallest recorded difference from the standard cast. This agrees with what Fraile et al found regarding how it provides better dependability to register interocclusal contacts with digital methods.[17] The limitation of this study is the absence of the humidity of the oral cavity which may affect the properties of bite registration materials. In-vivo studies will be needed to consider this factor.

Conclusion

Throughout this study, the results showed that all the mentioned methods had some discrepancies and differences. The intra oral scanner and the condensation silicone provided greater accuracy while the dental wax had the least.

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Conflict of interest

Authors declare no conflict of interest.

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