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Comparison between the Accuracy of Computer Aided Indirect Bracket Positioning with and without CBCT: A Randomized Clinical Trial

Sara EL-gwaily, Ibrahim Mazen Negm** and Islam Tarek Abbas****

Abstract:

Objectives: The aim of this study is to compare the accuracy of computer-aided indirect bracket positioning with and without CBCT.

Design: 2 arm parallel randomized controlled trial with an allocation ratio of 1:1.

Setting: The outpatient department of the dental college, Ain Shams University

Participants: 20 adult patients full set of permanent dentition.

Methods: The experimental group consisted of 10 patients. Computer aided indirect bracket positioning was then performed for both groups. Bracket angulation was adjusted guided by clinical crowns for CBCT.UG group, while for the CBCT.G group it was adjusted according to roots angulations of CBCT. Post alignment and leveling teeth angulations were measured on post treatment CBCT superimposed on post treatment intra-oral scan taken on the same day for both groups.

Results: Data showed statistically significant difference between teeth angulations for CBCT.G group compared to CBCT.UG group regarding UR3 and LL1. ($p<0.05$).

Conclusion: The results showed that Computer aided indirect bracket placement using 3Shape software can be considered as an accurate method for computer aided orthodontic indirect bonding. Root guidance by adding CBCT to the bracket placement procedures added more accuracy for post alignment and levelling teeth angulations.

*Teaching assistant, orthodontic department, Faculty of dentistry, Ain Shams University
** Associate-Professor of Orthodontics , faculty of dentistry, Ain Shams University
***Professor of Orthodontics, Faculty of dentistry, Ain Shams University

Introduction

In the early 1970s, Straight wire appliance was 1st introduced by ***Larry Andrews*** who changed the minds for ideal orthodontic treatment from being an issue of wire bending skills to becoming basically a matter of perfect bracket positioning.[1]

Since successful orthodontic treatment needs to be not only effective but efficient as well, thus the aim of orthodontists is to achieve the most ideal treatment outcome in the shortest treatment time with the least patient discomfort.

Indirect bonding (IDB) technique was 1st introduced in 1972 by ***Silverman et al.*** aiming to make bracket positioning more precise via better visibility, in addition to reducing chair time and improved patient comfort.[2]

In the mid-1980s computer-aided design and computer-aided manufacturing (CAD/CAM) system was first used in the dental field and after then it became increasingly popular.[3,4]

As the innovative digital technology developes and improves, orthodontic diagnosis, treatment planning, bracket positioning and indirect bonding are all shifting to a completely computerized digital format. [5-6]

In 1999 OrthoCAD was the first to commercially introduce digital study models which offered multiple advantages among which are; no storage space, easy transfer and retrieving, simple manipulation sectioning and space analysis, digital diagnostic setup and indirect bracket placement.

Whatever the method for bracket positioning whether direct or indirect on plaster or digital models it's still based on the representation of the clinical crowns without taking into consideration the root orientation. Although one of the requirements for the ABO is the root parallelism as documented via panoramic radiograph.

Root parallelism is the cornerstone of micro-esthetics, proper occlusion, proper occlusal force distribution and post-orthodontic treatment stability.[7–10]

However, recent investigations have shown that the ability of panoramic radiograph to accurately determine root angulation is limited due to magnification and possible distortion due to the large beam deviation resulting from the perpendicular distance object and film. [11–13]

Recent studies have compared panoramic radiograph to CBCT and concluded that the mesiodistal root angulation was more accurately represented in CBCT.[14,15]

Therefore, the aim of our study was to compare the precision of mesiodistal tooth angulation after the first phase of comprehensive orthodontic treatment (alignment and leveling) via computerized indirect bracket positioning based on the long axis of the clinical crown on 3D digital model only to that guided by the whole tooth on a 3D digital model superimposed on CBCT and computerized indirect bracket positioning based on the long axis of the tooth on 3D digital models in which teeth are superimposed via best fit method on digital CBCT.

MATERIAL AND METHODS

The sample was recruited from the outpatient' clinic of the Orthodontic Department, Faculty of Dentistry, Ain-Shams University. The sample consisted of 20 adult patients that have all permanent teeth from 1st molar to 1st molar with no history of systemic disease affecting bone or teeth and no crown fractures or restorations.

The patients were randomly allocated to one of 2 groups either CBCT.G group or CBCT.UG group. Two patients in the CBCT.G group and three patients in the CBCT.UG group were lost to follow up. The final sample included 8 patients in CBCT.G group and 7 patients in the CBCT.UG group

Methods After taking full orthodontic records, patient's orthodontic models were scanned. Computer aided indirect bracket positioning was then performed for both groups. Bracket angulation was adjusted guided by clinical crowns for CBCT.UG group, while for the CBCT.G group it was adjusted according to roots angulations of CBCT.

Bracket transfer trays were then designed, printed and loaded with 0.022 inch dentaurum discovery brackets with ROTH prescription. Clinical procedures including isolation, etching and brackets t bonding were then performed.

Patients were followed up once every three weeks until complete alignment and leveling phase was finished and 0.017 x 0.025 inch TMA wires were found to be passive in both arches.

Methods of assessment Intra-oral scan and CBCT were then taken for patients of both groups. Post alignment and leveling teeth angulations were measured on post treatment CBCT superimposed on post treatment intra-oral scan taken on the same day for both groups. Teeth angulations were compared for each group with normal range of teeth angulations. Also, teeth angulations were compared for both groups.

Error of measurement The error of measurement in this study was assessed through assessing the intra-operator and inter-operator reliability.

Statistical Analysis Data was collected, revised, coded and entered to the Statistical Package for Social Science (IBM SPSS) version 23.The distribution of the quantitative parameters was checked by using ***Kolmogorov-Smirnov test*** of normality. The quantitative data were presented in the form of mean, standard deviations (SD) and standard error (SE).

The comparison between teeth angulations for the two groups with quantitative data and parametric distribution were done by using ***Independent t-test*** while non-parametric distribution was done by using ***Mann-Whitney test***.

Results

Post alignment and leveling angulations of the upper and lower anterior and premolar teeth were measured and compared for both groups.

The comparison between two groups with quantitative data and parametric distribution were done by using ***Independent t-test*** while non-parametric distribution was done by using ***Mann-Whitney test***.

Data showed no statistically significant difference between teeth angulations for CBCT.G group compared to CBCT.UG group regarding the UR1, UR2, UR4, UR5, UL1, UL2, UL3, UL4, UL5, LL2, LL3, LL4, LL5, LR1, LR2, LR3, LR4 and LR5.

Data showed statistically significant difference between teeth angulations for CBCT.G group compared to CBCT.UG group regarding UR3 and LL1.

Table (1): ***Mean, standard deviation (SD) values and results of independent t-test for comparison between teeth angulations for CBCT.G group and CBCT.UG group regarding UR1-UR5***

Tooth	CBCT.G	CBCT.UG	Test value•	P-value	Sig.
	Mean ± SD	Mean ± SD			
UR1	4.14 ± 2.14	4.02 ± 2.89	0.094	0.926	NS
UR2	6.87 ± 3.60	5.10 ± 3.81	0.928	0.371	NS
UR3	10.98 ± 1.21	13.22 ± 2.45	-2.301	0.039	S
UR4	7.59 ± 2.47	8.27 ± 4.56	-0.369	0.718	NS
UR5	5.00 ± 2.40	5.95 ± 3.56	-0.619	0.546	NS

P > 0.05: Non significant; P < 0.05: Significant; P < 0.01: Highly significant

•: Independent t-test

Table (2): Mean, standard deviation (SD) values and results of independent t-test for comparison between teeth angulations for CBCT.G group and CBCT.UG group regarding UL1-UL5

Tooth	CBCT.G	CBCT.UG	Test value•	P-value	Sig.
	Mean ± SD	Mean ± SD			
UL1	3.01 ± 0.62	3.03 ± 1.58	-0.040	0.969	NS
UL2	5.42 ± 2.84	5.93 ± 2.14	-0.384	0.707	NS
UL3	11.63 ± 2.84	11.13 ± 0.90	0.444	0.664	NS
UL4	8.01 ± 3.30	6.50 ± 2.44	0.995	0.338	NS
UL5	6.24 ± 2.63	3.52 ± 2.24	2.135	0.052	NS

Table (2): ***Mean, standard deviation (SD) and results of independent t-test and Mann-Whitney test for comparison between teeth angulations for CBCT.G group and CBCT.UG group regarding LL1-LL5***

Tooth	CBCT.G	CBCT.UG	Test value	P-value	Sig.
	Mean ± SD	Mean ± SD			
LL1	-1.44 ± 1.89	-3.96 ± 2.47	2.236#	0.044	S
LL2	-1.41 ± 3.52	-2.50 ± 4.11	0.557#	0.587	NS
LL3	4.82 ± 2.26	5.45 ± 3.66	-0.404#	0.693	NS
LL4	5.93 ± 3.07	5.35 ± 4.05	0.315#	0.758	NS
LL5	8.05 ± 2.82	8.94 ± 5.57	-0.401•	0.695	NS

Table (3): ***Mean, standard deviation (SD) and results of independent t-test and Mann-Whitney test for comparison between teeth angulations for CBCT.G group and CBCT.UG group regarding LR1-LR5***

Tooth	CBCTG	CBCTUG	Test value	P-value	Sig.
	Mean ± SD	Mean ± SD			
LR1	0.19 ± 2.82	1.79 ± 1.40	-1.357#	0.198	NS
LR2	-2.65 ± 2.34	-0.55 ± 3.66	-1.340#	0.203	NS
LR3	6.55 ± 2.75	9.38 ± 3.57	-1.734#	0.107	NS
LR4	6.71 ± 1.93	8.89 ± 4.12	-1.350#	0.200	NS
LR5	8.70 ± 2.85	8.87 ± 2.45	-0.121•	0.906	NS

Discussion

This study addresses three major problems traditionally associated with orthodontic treatment: inaccurate bracket positioning, prolonged chair time and the long time needed for precise finishing. This was discussed via our aim, which was to compare the accuracy of computer-aided indirect bracket positioning with and without CBCT.

For this study, sample size was calculated using a G*power 3.1.5 program for power analysis based on a study by **Kim**[67]second premolar, first molar**,** error probability was set as 0.05 with desired power of 80%. The power analysis generated a total sample size of 18 patients with 9 patients in each group. To further increase the power of the study, we included a total of 20 participants (10 in each group).

In our study, computer-aided indirect bracket positioning was employed to make use of bracket positioning optimization offered by CAD/CAM technologies and to overcome drawbacks associated with traditional indirect bracket positioning techniques

For our study, 3Shape software was chosen for the various applications available through its Ortho system software. This software provides different orthodontic analyses and treatment planning services. It also provides tools for designing many different orthodontic appliances. In addition to the privilege of having three different methods for indirect bracket transfer, including either printing the 3D model or directly printing the IBT, making the indirect bonding procedure more flexible and compatible to more printing materials available.

In our study, Brackets were positioned with 3Shape Ortho Analyzer software utilities that verifies height, mesiodistal position, and angulation. Default heights were then modified according to Larry white protocol[114] in order to achieve best results regarding occlusion and marginal ridge alignment.

Angulations were adjusted parallel to clinical crown long axis in CBCT.UG group. Whereas for the CBCT.G group, implementing CBCT offered the privilege of root visualization during the bracket positioning stage. CBCT is the modality by which the particular root position can be detected and consequently precise bracket placement parallel to the root long axis could be achieved. This was claimed in previous studies[68,152] to ensure more precise teeth angulations, post treatment root parallelism, stability, better periodontal health and force distribution.

In our study, IBT design was a double shell tray with different extensions for both shells. This offered optimum rigidity for the occlusal part without affecting the flexibility needed for the gingival part covering brackets so that brackets can fit well and the tray can be easily removed after bonding.

Trays were printed in NeXTDent Ortho IBT printing material. This material showed excellent stability and sufficient flexibility giving us the opportunity to cover the whole bracket gaining more bracket-tray retention. In addition to its transparency which allowed the use of light cured composite and ensured full curing.

Teeth angulations were measured and compared to normal ranges according to ***Hongsheng Tong et al*** 2011.[48]

In our study results showed that, compared to normal ranges, post alignment and leveling teeth angulations for CBCT.G group showed no statistically significant difference except for UL1. For the CBCT.UG group there was also no statistically significant difference compared to normal teeth angulations except for UL1, LR3 and LL1.

Both methods proved to be accurate methods for computer aided indirect bracket positioning. However, CBCT.G group showed superiority over CBCT.UG group regarding UR3 and LL1 teeth angulations.

CBCT.UG group results also showed statistically significant difference between right and left teeth angulations regarding L1, L3 and L4. It could have been due to some misleading anatomical clinical crown variations. CBCT guidance adds more privilege during bracket positioning especially for cases with anatomical variations (eg peg shaped laterals and teeth with attrition).

Conclusion

Computer aided indirect bracket placement using 3Shape software is considered an accurate method for orthodontic indirect bonding.

Root guidance by superimposing CBCT to patient's digital model during bracket placement procedures added more accuracy for post alignment and levelling teeth angulations regarding UR3 and LL1.

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