Mandibular Condylar Guidance Obtained by Panoramic Imaging in Edentulous Subjects

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ABSTRACT

Objectives: To verify the reproducibility of condylar guidance in a group of edentulous patients.

Methods: Panoramic radiographs of completely edentulous patients from both genders were randomly collected from patients attending prosthodontic clinics. Inclusion criteria were patients who were completely edentulous with a normognathic jaw relation. Five specialists in prosthodontics and five prosthodontic residents traced each radiograph. The prosthodontists identified the most superior point on the glenoid fossa and the most inferior point on the articular eminence, and they joined these bony points by a straight line. Another reference line representing the Frankfort horizontal plane was made by joining the orbitale and porion. Angles made by the intersection of these two lines were measured to represent the condylar guidance on each side.

Results: Twenty panoramic radiographs fulfilled the criteria of this study. The standard deviation of the right side mean angle value did not exceed 1.24 degrees and on the left side, the standard deviation did not exceed 1.31 degrees. The difference between the minimum and maximum condylar guidance on the right and left sides did not exceed four degrees.

Conclusion: Panoramic images are a useful and reproducible tool for the measurement of condylar guidance in edentulous patients. Condylar guidance measurement by panoramic images is a relatively easy method that could be applied in dental rehabilitation clinics, but it requires proper training to avoid the minimal condylar guidance discrepancies that could lead to some degree of potential occlusal errors.

Keywords: Condylar Guidance; Condylar Angle; Frankfort's Horizontal Plane; Panoramic Radiograph Images; The Royal Medical Services

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INTRODUCTION

In 1756, Phillip Pfaff, a German dentist, made the first attempt to measure and replicate the condylar guidance (1). Condylar guidance is one of the essential factors for occlusion (2). Modern dentistry uses several methods for condylarguidance measurement, such as wax records, Gothic arch measurement, the intraoral check-bite method, cephalometric, and computerized graphic tracings (3–5).

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However, these conventional methods have some major drawbacks, such as measurement errors, operator-dependent results and instability of the materials used for measurements (3, 6). In addition to this, some of these measurement methods are costly, meaning that developing countries find it difficult to make them available for use in dental rehabilitation clinics (4). Condylar guidance is crucial for fabricating a fixed or removable dental prosthesis. Finding a reliable method to measure the relationship between teeth and arches is particularly tricky, painstaking and time-consuming (3,6).

Meanwhile, panoramic radiograph images are a widely available diagnostic tool that is present in almost all dental clinics. Panoramic radiograph images are also a cost-effective tool and constitute a non-invasive evaluation method with minimal radial exposure (7). Evaluating the possibility of using panoramic images for condylar guidance measurement could benefit many patients who are in the process of dental rehabilitation (8).

The study presented here aimed to verify the reproducibility of condylar guidance in a group of edentulous Jordanian patients.

METHODS

This research is a descriptive prospective study. Panoramic radiographs for completely edentulous patients from both genders were randomly collected from patients attending prosthodontic clinics at the King Talal, Prince Rashid and Prince Ali Military Hospitals.

The study inclusion criteria were patients who were completely edentulous with a normognathic jaw relation., while the exclusion criteria were patients with poorly resorbed ridges, lack of adequate neuromuscular control, a history of temporomandibular disorder and a history of mandibular trauma or surgery to the temporomandibular joint (TMJ).

Data were collected in September 2020. Primary investigators randomly selected study patients. Demographic data were collected and a proper panoramic radiograph was made with a Frankfort horizontal (FH) plane parallel to the floor of the mouth. A cephalometer was used to capture the standardized aligned head position for all patients. All low-quality X-rays were excluded from this study.

Out of the sixty panoramic radiographs that fulfilled the study's criteria, only twenty radiographs, selected evenly from female and male patients, were presented to the dentists participating in this study.

Ten copies of each radiograph were made for tracing by 10 different dentists. Five of the dentists were specialists in prosthodontics, and five were prosthodontic residents. Each prosthodontist identified the most superior point on the glenoid fossa and the most inferior point on the articular eminence and they joined these bony points by a straight line. Another reference line representing the Frankfurt horizontal plane was made by joining the orbitale (the lowest point in the margin of the orbit) and the portion (the highest point on the auditory meatus). Angles made by the intersection of these two lines were measured to represent the condylar guidance on each side (9,11) (Figure 1).

An accurate impression of one patient was made using alginate irreversible hydrocolloid and immediately poured into themodel stone (Type-III). After instructing the randomly selected patient to move the mandible directly forward by 6 mm using a Lucia jig, a 6 mm protrusive record was made. The cast was then mounted on a semi-adjustable Hanau articulator using a dental facebow. The condylar guidance recorded on the articulator were then compared with the condylar guidance obtained by panoramic radiograph.

Without informing the prosthodontists about the condylar guidance obtained by the protrusive record, the primary author briefly explained the method of identifying each bony point and how the lines could be drawn. The primary author then did a demonstration on one panoramic radiograph before asking the participants to measure the condylar guidance of the selected radiographs.

Condylar guidance is defined as the mandibular guidance, which is a mechanical function generated by the condyle and articular disk traversing the contour of the glenoid fossa (8,12).

Anonymous data were numerically coded and entered into an Excel sheet (Microsoft® Office Excel). The data were then analyzed using SPSS statistical data analysis software (IBM Corporation, version 25.0). Descriptive analysis and the Mann-Whitney U test were used to analyze the data. Data were interpreted as statistically significant when a p-value was less than 0.05.

Approval for this research was obtained from the Research Ethics Committee of the Jordanian Royal Medical Services. A briefing about the purpose of the study was given to the patients by the investigators, and verbal, voluntary informed consent was then obtained from all participants and patients. No identifying data were collected. This research was carried out in accordance with the Helsinki Declaration.

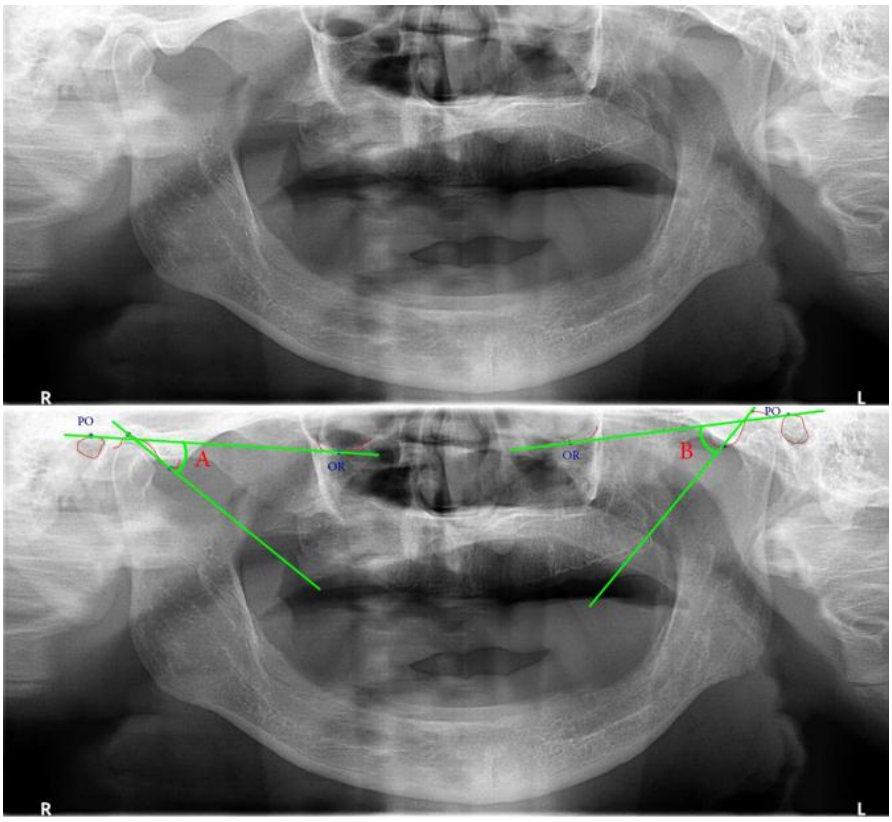

Figure 1 Example of included panoramic Images in edentulous subjects before and after marking the bony points by straight lines. The angle (A and B) formed by the intersected lines on both sides represents the condylar guidance.

RESULTS

In total, 20 panoramic radiographs fulfilling the criteria of this study were presented to the prosthodontists. Half of the selected radiographs were for female patients and the other half for male patients.

The radiographs were of completely edentulous patients between the ages of 48 and 72.

The differences between condylar guidance measured by the protrusive record and the panoramic radiograph of the randomly selected edentulous patient were not statistically significant on both sides with a p-value of 0.909 and 0.727 on the right and left side, respectively (Table I).

The difference between the specialist and resident prosthodontists in terms of the mean slope value of line A and line B on both sides was not statistically significant (all p-values were >0.05)(Table II). The mean and standard deviation (SD) of slopes A and B on the right and left side for the 20 randomly selected radiographs, in addition to the minimal and maximal slope values, are demonstrated in (Table III).

The SD of the right side mean angle value did not exceed 1.24 degrees and for the majority of the radiographs, it did not exceed one degree. Similarly, on the left side, the SD did not exceed 1.31 degrees and for the majority of the radiographs, it did not exceed one degree (Table IV).

The difference between the minimum and maximum condylar guidance on the right side did not exceed three degrees in all cains (except is one case, which reached four degrees). Likewise, the difference between the minimum and maximum condylar guidance on the left side did not exceed three degrees in 17 out of 20 cases and it reached three degrees in 3 out of 20 cases (Table IV).

Method	Side	Number of measurements	Condylar angle	p-value
Panoramic radiograph	Right	10	Mean ± SD 33.6 ± 0.8	0.909
Protrusive record	Right	1	33.7	
Panoramic radiograph	Left	10	Mean ± SD -30.5 ± 0.9	0.727
Protrusive record	Left	1	-30.3	

Table I Distribution of condylar guidance values obtained from the protrusive record and the panoramic radiograph methods of one randomly selected edentulous patient

Slope	Residents measurements		Specialists measurements		p-value
	Mean	Standard deviation	Mean	Standard deviation	
Line A (left side)	-0.14	0.01	-0.14	0.01	0.511
Line A (right side)	0.14	0.01	0.14	0.01	0.052
Line B (left side)	-0.79	0.03	-0.79	0.02	0.415
Line B (right side)	0.90	0.03	0.90	0.02	0.102

TableII Comparison between specialists and resident measurements for line A and B slopes

Slope		Mean	Standard deviation	Min	Max
Patient 1	Line A (left side)	-0.14	0.01	-0.14	-0.13

	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.78	0.03	-0.83	-0.75
	Line B (right side)	0.89	0.02	0.86	0.93
Patient 2	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.14	0.01	0.12	0.15
	Line B (left side)	-0.79	0.02	-0.82	-0.76
	Line B (right side)	0.90	0.03	0.86	0.94
Patient 3	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.80	0.03	-0.83	-0.75
	Line B (right side)	0.90	0.03	0.86	0.94
Patient 4	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.79	0.03	-0.83	-0.75
	Line B (right side)	0.91	0.03	0.86	0.94
Patient 5	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.14	0.01	0.13	0.14
	Line B (left side)	-0.79	0.02	-0.83	-0.76
	Line B (right side)	0.90	0.02	0.86	0.93
Patient 6	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.79	0.03	-0.83	-0.75
	Line B (right side)	0.91	0.03	0.86	0.94
Patient 7	Line A (left side)	-0.13	0.00	-0.14	-0.13
	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.80	0.02	-0.83	-0.76
	Line B (right side)	0.90	0.02	0.86	0.93
Patient 8	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.79	0.03	-0.83	-0.75
	Line B (right side)	0.89	0.03	0.86	0.94
Patient 9	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.13	0.00	0.13	0.14
	Line B (left side)	-0.79	0.02	-0.83	-0.75
	Line B (right side)	0.90	0.02	0.87	0.93
Patient 10	Line A (left side)	-0.14	0.00	-0.15	-0.14
	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.79	0.02	-0.83	-0.75
	Line B (right side)	0.89	0.03	0.86	0.94
Patient 11	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.14	0.00	0.14	0.15
	Line B (left side)	-0.79	0.03	-0.83	-0.75
	Line B (right side)	0.89	0.02	0.86	0.92
Patient 12	Line A (left side)	-0.14	0.01	-0.14	-0.13
	Line A (right side)	0.14	0.00	0.13	0.14
	Line B (left side)	-0.78	0.03	-0.83	-0.75
	Line B (right side)	0.89	0.02	0.86	0.92
Patient 13	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.79	0.02	-0.83	-0.75
	Line B (right side)	0.89	0.02	0.86	0.93
Patient 14	Line A (left side)	-0.14	0.00	-0.14	-0.13
	Line A (right side)	0.14	0.00	0.13	0.14
	Line B (left side)	-0.79	0.03	-0.83	-0.75

	Line B (right side)	0.90	0.03	0.86	0.94
Patient 15	Line A (left side)	-0.14	0.01	-0.15	-0.13
	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.79	0.02	-0.81	-0.77
	Line B (right side)	0.91	0.04	0.86	0.94
Patient 16	Line A (left side)	-0.14	0.01	-0.14	-0.13
	Line A (right side)	0.14	0.01	0.13	0.15
	Line B (left side)	-0.78	0.02	-0.81	-0.75
	Line B (right side)	0.90	0.02	0.86	0.94
Patient 17	Line A (left side)	-0.14	0.01	-0.14	-0.13
	Line A (right side)	0.14	0.01	0.13	0.14
	Line B (left side)	-0.79	0.03	-0.83	-0.75
	Line B (right side)	0.91	0.02	0.86	0.94
Patient 18	Line A (left side)	-0.14	0.00	-0.14	-0.13
	Line A (right side)	0.14	0.01	0.13	0.14
	Line B (left side)	-0.80	0.02	-0.83	-0.78
	Line B (right side)	0.91	0.02	0.86	0.94
Patient 19	Line A (left side)	-0.14	0.01	-0.14	-0.13
	Line A (right side)	0.14	0.00	0.13	0.14
	Line B (left side)	-0.79	0.03	-0.83	-0.76
	Line B (right side)	0.91	0.03	0.86	0.94
Patient 20	Line A (left side)	-0.14	0.00	-0.15	-0.13
	Line A (right side)	0.14	0.00	0.13	0.15
	Line B (left side)	-0.79	0.03	-0.83	-0.75
	Line B (right side)	0.89	0.02	0.86	0.92

Table III Slopes A and B for 20 randomly selected radiographs

Patient #	Sex	Age	Right mean angle	SD	Min	Max	Left meanangle	SD	Min	Max
1	Female	60	33.87	0.78	32.16	34.64	-30.15	1.07	-32.29	-28.90
2	Female	64	34.39	1.04	32.73	35.82	-30.52	0.98	-31.94	-29.27
3	Female	72	34.09	0.98	32.73	35.82	-30.68	1.22	-32.29	-28.90
4	Female	57	34.42	1.04	32.82	35.82	-30.46	1.11	-32.29	-28.34
5	Female	62	34.26	0.63	33.29	34.95	-30.28	0.92	-31.72	-29.27
6	Female	71	34.41	0.92	33.14	35.82	-30.24	0.80	-31.16	-28.90
7	Female	48	34.16	0.62	33.14	34.95	-31.15	0.78	-31.94	-29.27
8	Female	63	33.51	1.23	32.16	35.82	-30.17	1.14	-32.29	-28.34
9	Female	59	34.53	0.67	33.38	35.52	-30.27	0.97	-31.72	-28.34
10	Female	63	33.87	0.89	32.73	35.26	-30.42	0.80	-31.72	-28.90
11	Male	50	33.56	0.67	32.49	34.33	-30.37	1.31	-32.29	-28.34
12	Male	54	33.75	0.69	32.73	35.21	-30.05	1.11	-31.94	-28.90
13	Male	61	33.87	0.68	32.73	34.95	-30.04	0.81	-31.72	-28.90
14	Male	58	34.30	0.97	32.73	35.82	-30.60	1.30	-32.29	-28.90
15	Male	71	34.28	1.24	32.49	35.82	-30.40	0.69	-31.60	-29.63
16	Male	63	34.23	0.59	33.29	35.21	-30.17	0.78	-31.25	-28.90
17	Male	55	34.42	0.74	33.29	35.82	-30.71	1.23	-32.29	-28.90
18	Male	64	34.52	0.87	32.73	35.82	-30.94	0.78	-32.29	-29.98
19	Male	56	34.46	0.84	32.73	35.26	-30.70	0.89	-32.29	-29.27
20	Male	49	33.57	0.79	32.49	34.90	-30.47	0.89	-31.72	-28.90

Table IV Right and left side mean angle for 20 randomly selected radiographs

DISCUSSION

Previous studies have produced inconclusive results in terms of the possibility of using panoramic images for condylar guidance (9,10). Prasad et al. reported that panoramic images are an excellent and reliable alternative for condylar guidance measurement (9). Another recent study reported that panoramic radiographs are accurate only in completely edentulous patients due to high variability in environmental and tissue conditions when conventional measurements are taken, compared with relatively easily identified bony structures in panoramic images (4). On the other hand, Loster et al. concluded in two consecutive studies that panoramic images are not a reliable method for condylar guidance measurements (10,11). Similarly, in 2019, Dewan et al. conducted a comparative study in Saudi Arabia and reported that conventional measurement methods are preferable for evaluating condylar guidance, while Katiyar et al.'s results were inconclusive (3,8).

The results of the current study indicate that panoramic images could be used to measure the condylar guidance angle. The SD of the mean angle was <1.4 degrees on both sides for all randomly selected panoramic radiographs. This finding is in line with Gilboa et al. and Weinberg's findings which indicated the possibility of using panoramic images as a substitute for condylar guidance measurement (13,14). On the other hand, Loster et al. reported in two published articles that panoramic images could not be used to measure the condylar guidance (10,11). Differences in study methodology could explain the variation between the results of the current study and those of Loster et al. results. Loster et al. reached their conclusion based on the repeatability of only one panoramic image, while the current study included 20 randomly selected radiographs. Furthermore, in Loster et al.'s studies, different types of dentists and students were included while in the current study, more coherent group of only prosthodontic specialists and residents were included (10,11).

Although some differences in the condylar guidance were detected in the current study results on both sides, these differences were less than five degrees between the minimum and maximum measurements, and in most cases, these ranged between two and three degrees. The rigorous explanation and demonstration of bone marks identification and lines drawing methods might have led to these minimal angle differences compared with Loster et al.'s findings (10). However, these minimal condylar guidance angle differences could still lead to some degree of occlusion relation challenges for prosthesis fitting in clinical and rehabilitation settings (3). Therefore, there is still a need for proper training and practice on the methodology of identifying bone marks for measurement of the condylar guidance angle (12).

In addition, when the condylar guidance angles obtained by panoramic radiographs were compared to the angles obtained by the traditional method of a protrusive record, the difference was not statistically significant. Khalikar et al. and Bhandari et al. reached the same results in two research studies involving edentulous patients (15,16). However, due to the challenging effects of anatomical and physiological factors, Godavarthi et al. reported that the angles could differ significantly in dentulous patients (4).

The modern dental industry tends to adopt the latest technological advances, leading to better and more accurate measurement results and, eventually, better services for patients (17,18). However, budget limitations and the cost implications of such technological advances could lead to a narrow scope of services and become a barrier for dental and rehabilitation care for the wider population especially in developing countries (19,20). The current study and several other studies have concluded that panoramic images are an appropriate alternative tool for condylar guidance measurement and this is a repeatable measurement that is suitable for settings with limited resources (4,5,13,21).

The limitation of this study is that it only included specialists and resident prosthodontists, which could limit generalization of the repeatability of panoramic images for condylar guidance measurement by general dentists and other specialists. In addition, in clinical settings, panoramic distortion could be a

major obstacle to its use for condylar guidance measurement, while in the current study, all poor-quality radiographs were excluded (9). Finally, different X-ray machines were used to take the selected panoramic images and an X-ray machine type was outside the scope of the current study.

On the other hand, the current study has several strong points such as using a large number of randomly selected panoramic images and involving 10 different prosthodontic specialists and residents in condylar guidance measurement. In addition, the patients included were from both genders and different age groups which could help with the generalization of the study results.

CONCLUSION

Within the limitations of the current study, it can be concluded that panoramic images are a useful and reproducible tooth1 for measurement of condylar guidance in edentulous patients, compared with traditional methods. However, there is a need for further largescale studies to compare the results of condylar guidance obtained by the panoramic images with other methods of measurement. Condylar guidance measurement by panoramic images is a relatively easy method that could be applied in dental rehabilitation clinics with limited settings, but it needs to be associated with proper training and the use of standard methods for identifying bone marks in radiographs to avoid the minimal condylar guidance discrepancies that could lead to some degree of potential occlusal errors.

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