

TMJ Changes Before and After Implant of Posterior Partial Edentulous Patients Free of TMD Signs Under the Scope of Cadiax Compact II Device

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KEYWORDS

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ABSTRACT

Introduction: Assessing occlusion and TMJ discrepancies presents a persistent challenge for health professionals due to the complexity of the conditions that include accurate: diagnostic methods, treatment, associated comorbidities. Researches are being delved in this field. Cadiax Compact II is one of the technological innovations that can analyze and provide a simple and minimally invasive way, enabling early preventive action and treatment with a long-term impact on the good functioning of the masticatory system. **Objectives:** The objective of this research is to evaluate TMJ changes among dental implant patients. A comparison of the implant impact on posterior partial edentulous patient is taken place by the aid of Cadiax Compact II. Cadiax Compact II investigates in parameters such as Immediate Side-Shift (ISS), Sagittal Condylar Guidance (SCG), and Transverse Condylar Guidance (TCG) that are derived from mandible movements (opening, closing, protrusion, retrusion, and lateral excursion). The objective is to evaluate the changes in TMJ before and after implants in partial edentulous (posterior teeth) patients. **Methods:** Condylography using Cadiax Compact II device (Gamma Dental, Klosterneuburg, Austria) was conducted on 40 patients. R statistical software was used to perform statistical analysis to perform a cephalometric analysis. **Results:** Age groups covered are (<40), (40-49), (50-59), and (≥ 60). Alpha value, level of uncertainty, was chosen to be 0.05. There is no statistical evidence in the change of ISS, SCG, and TCG before and after implant in the age groups (<40) and (40-49); however, there is a significant statistical change in age groups (50-59) and (≥ 60) with p-value <0.05. **Conclusions:** This research extended from December 2022 to March 2024 to cover time changes on mandible bone structure. The research outcomes revealed that implant has pronounced impact on TMJ articulation during opening, protrusion, retrusion, and lateral movements through (ISS, SCG, and TCG or so-called Bennet Angle) variables. Evidence-based statistical tests with p-value < 0.05 showed that (ISS, SCG, TCG, and Bennet Angle) variables changed in age groups (50-59) and (≥ 60) from abnormal ranges to the normal ranges after implant. However, no statistical evidence was approved of the implant impact on age groups (<40) and (40-49). Though these age groups have normal ranges before and after implants.

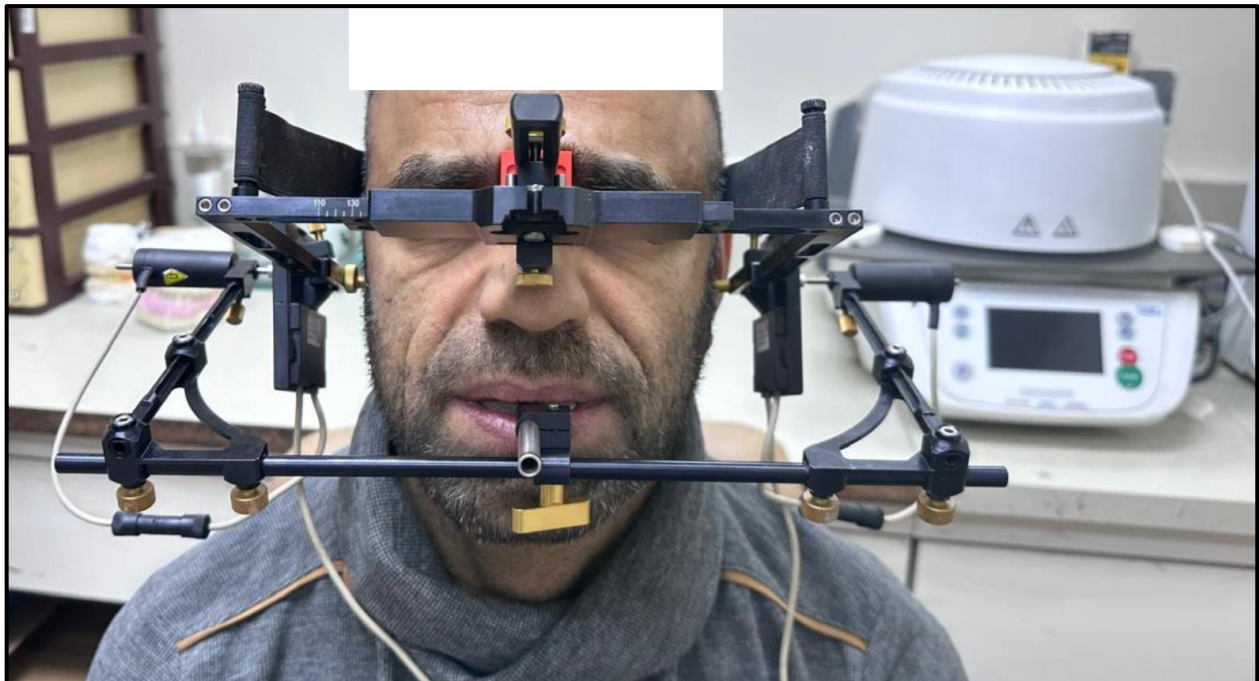
1. Introduction

The temporomandibular joint (TMJ) is a bilateral, dynamic, synovial and diarthrodial articulation between two common bones; the condylar process of the mandible and the temporal bone of the skull. The human TMJ shows a unique shape, function and structural characteristics. A fibrocartilaginous disc is filling the space between the mandible and the temporal bone (1). TMJ is technically ginglymoarthrodial joint that has a combination of hinge and sliding motions. Due to ginglymoarthrodial property of TMJ, TMJ is the most complicated joint in the body (2). The relationship between the incising or occlusal surfaces of the maxillary and mandibular teeth is called Occlusion. Occlusal forces should be in balance on both sides of the arch. In contrast, adverse occlusal forces that occur when teeth contact is improperly can affect all parts of the stomatognathic system: the teeth, periodontium, masticatory muscles, and temporomandibular joints (3). The last three decades has witnessed a notable increase of using dental implants to rehabilitate the loss of teeth (4). Dental implants have become mainstream strong substitute of dentures and due to the high success rate and systematic procedure of fixing (5). Cadiax Compact®II is accurate and reliable device in recording the relative anatomy of condylar guidance in clinical practice. Technically, the device is sensitive, the results are reproducible and accurate. It allows computerized recording of the opening, protrusion, and lateral excursion, and it calculates the Immediate Sideshift (ISS), sagittal condylar guidance (SCG) and transversal condylar guidance (TCG) in numeric values (6,7). Cadiax compact II device was used in diagnosis and treatment in many studies (8–11). The use of modern

axiographic device provides a simple and non-invasive way, enabling early preventive and therapeutic measures, which are of great importance in efficient dental treatment (12). Temporomandibular disorders (TMDs) patients can be clinically diagnosed by a simple quick test called Helkimo Clinical Dysfunction Index (HCDI). HCDI is a valid and reliable assessment diagnosis too that has great capability to differentiate between TMD-affected and unaffected subjects (13). So far, none study has been delved to find the relationship between posterior partial edentulous patients and the impact of implants on TMJ. This study sheds the light on implant impact in partial edentulous patients before and after implant. So far, no significant evidence about impact of implant in partial edentulous patients.

2. Materials and Methods

Forty patients were participated in this research. The participants were 12 males and 28 femPatients aged from 24 to 73 years old. The mean is 49 and the standard deviation is 11. The total number of implant units implanted to volunteers is 91. The longitudinal study was carried out from December 2022 to March 2024.



The volunteers were recruited. The age groups are divided into (<40 , 40-49, 50-59, and ≥ 60). The number of implants ranges from one to six, and the corresponding number of implants with respect to site of implant was 22 in the Upper Left UL, 23 in the Upper Right UR, 28 in the Lower Left LL, and 18 in the Lower Right LR. The study protocol was approved by the research ethics committee of the College of Dentistry, University of Baghdad (696722 /2022). Rules of declaration of Helsinki of 5, revised in 2013 of ethical principles for medical research was followed during working with patients. Written consents for participation were taken from patients. The evaluation of stomatognathic system was the main concern during medical interview and dental examination. The inclusion criteria included patients who are 16 years or older with posterior partial edentulous having intact healthy TMJ free of Temporomandibular disorder (TMD) signs. The exclusion criteria had not included what have been mentioned in the inclusion criteria in addition to patients with, systemic disease, epilepsy and Parkinson patients. Primarily, Helkimo clinical case sheet was used to exclude TMD patients. Condylography using Cadiax Compact II device (Gamma



Dental, Klosterneuburg, Austria) by the aid of Denar Mark II articulator was used to measure Immediate Side-Shift (ISS), Sagittal Condylar Guidance (SCG), and Transverse Condylar Guidance (TCG) data as shown in Figure 1 and 2. Mandible movements were instructed and patients were asked to practice before actual condylography. Mandible motions included maximum opening, protrusive, retrusive, mediotrusion left and right respectively. All the measurements with the correspondent movements were registered and recorded carefully. The results were statistically analyzed using R statistical software (14). Mean values of ISS, SCG, and TCG were compared before and after implant using student's T-test paired two samples for means. ISS, SCG, and TCG showed normal distribution according to the Shapiro-Wilk's test. The null hypothesis assumed there is no change on TMJ in terms of ISS, SCG, and TCG parameters before and after implant whereas the alternative hypothesis assumed the opposite that there is a change in TMJ after implant. Alpha was set to 0.05.

3. Results

The ages range from 24 to 73. Shapiro-Wilk's test p-value is greater than 0.05; therefore, null hypothesis is accepted and data is normally distributed. ISS, SCG, and TCG Cadiax Compact II parameters are crucial in the assessment of TMJ before and after implant. ISS represents the rotation of the working condylar whether perfectly pure or has a side shift in addition to the rotation. Normal range of ISS ranges between (0 – 2 mm). SCG represents the path and inclination of the condyle during mandible motion on the sagittal plane during protrusion and retrusion of mandible and the normal range is (25-45 mm). Additionally, TCG or so-called Bennet angle represent the angle between non-working condylar and sagittal plane on the horizontal plane. Table 1 reflects ISS data. ISS represents the bodily movement of the condylar during lateral movement. The table presents measured data of patients before and after implant. There is no statistical evidence about the change in ISS values before and after implant for age groups (<40) and (40 -49) for both males and females and mean ISS is within acceptable range (0 – 2 mm). However, there is significant statistical evidence change in ISS after implant with p-value is 0.04 for Left ISS (LISS) for men in age group (50-59) also for female with p-value is highly significant.

Age	Sex	Left Immediate Side Shift (LISS)			Right Immediate Side Shift (RISS)		
		Pre-I	Post-I	P-value	Pre-I	Post-I	P-value
<40	M	0.4±0.1	0.1±0.2	0.4	0.2±0.1	0.1±0.1	0.15
	F	0.2±0.1	0.2±0.2	0.48	0.2±0.1	0.2±0.2	0.18
	Total	0.2±0.1	0.15±0.16	0.27	0.3±0.1	0.2±0.1	0.09
40-49	M	0.1±0.05	0.25±0.17	0.2	0.2±0.1	0.2±0.1	0.37
	F	0.1±0.1	0.1±0.2	0.25	0.1±0.2	0.1±0.1	0.43
	Total	0.01±0.24	0.002±.2	0.5	.07±0.19	0.06±0.19	0.47
50-59	M	2.43±0.5	0.63±0.5	0.04 ^s	2.14±0.75	1.37±0.15	0.08
	F	2.07±0.56	1.24±0.18	0.001 ^{HS}	2.12±0.48	1.15±0.33	0.004 ^{HS}
	Total	2.17±0.55	1.08±0.39	0.003 ^{HS}	2.13±0.52	1.21±0.3	0.007
≥ 60	M	2.35±0.43	1.47±0.56	0.01 ^s	3.75±0.32	1.18±0.42	0.001 ^{HS}
	F	3.96±0.42	1.42±0.67	0.02 ^s	4.35±0.82	1.37±0.09	0.05 ^s
	Total	2.81±0.88	1.45±0.53	0.004 ^{HS}	3.92±0.52	1.24±0.35	0.001 ^{HS}

HS mean highly significant and S means significant.

Females also showed statistically significant change after implant for Right ISS (RISS). Age group (≥ 60) revealed significant statistical evidence in the change of LISS and RISS mean values after implant. SCG parameter represents the path and inclination of the condyle during mandible motion on the sagittal plane. Protrusion and retrusion of the mandible are the result of condylar motion on the x-axis of the sagittal plane while opening and closing of the mandible is the condylar motion on the y-axis. SCG normal values range between (25 – 45 mm).

Table 2 represents the SCG data. both left and right condylar motion. For the age group (40-49), there is a statistically significant change for right sagittal condylar in male. The Mean ±SD after implant decreased from 44±13 to 33±6. Age group (50-59) presented a statically significant change

Age	Sex	Left Sagittal Condylar Guidance			Right Sagittal Condylar Guidance		
		Pre-I	Post-I	P-value	Pre-I	Post-I	P-value
<40	M	30±2	32±1	0.3	34±4	32±5	0.51
	F	35±2	35±5	0.37	37±5	38±6	0.46
	Total	34±4	36±5	0.32	37±5	37±6	0.49
40-49	M	43±9	24±5	0.06	44±13	33±6	0.023 ^s
	F	35±10	37±10	0.35	36±10	31±5	0.09
	Total	37±10	34±10	0.3	38±11	31±5	0.034
50-59	M	43.4±16.15	39.04±10.05	0.33	50.8±5.07	40.35±1.87	0.05 ^s
	F	48.76±8.85	37.24±9.11	0.03 ^s	47.11±11.61	41.03±4.69	0.08
	Total	47.3±10.65	37.73±8.89	0.02 ^s	48.11±10.12	40.84±4.02	0.01 ^s
≥ 60	M	54.61±4.83	36.97±4.7	0.001 ^{HS}	49.49±7.9	44.04±4.35	0.1
	F	55.64±12.7	45.96±3.22	0.27	57.63±1.49	39.93±7.21	0.07 ^s
	Total	54.9±6.54	39.54±5.97	0.001 ^{HS}	51.81±7.6	42.87±5.03	0.02 ^s

HS mean highly significant and S means significant.

for left sagittal condylar guidance for female only and for right sagittal condylar guidance for male only. Age group (≥ 60) showed statistically significant change for male only for LSCG and RSCG for female only. In addition to ISS and SCG, TCG was investigated as well. TCG or so-called Bennet angle which represent the angle between non-working condylar and sagittal plane on the horizontal plane. Table x-y showcases the conducted measurements. TCG ranges between (5 -20 degrees).

Table 3 presents TCG statistical values. It is clear there is no statically change of both sexes for age groups (<40) and (40-49) in terms of Mean $\pm$ SD for left and right SCG. However, there is a remarkable change for both sexes in the age groups (50-59) and (≥ 60). Condylographic tracings data of condylar movements can be assessed in terms of symmetry, quality, and quantity by using Cadiax Compact II through registering TMJ movement. Cadiax Compact II has been reported as reliable

Age	Sex	Left Transverse Condylar Guidance			Right Transverse Condylar Guidance		
		Pre-I	Post-I	P-value	Pre-I	Post-I	P-value
<40	M	6 $\pm$ 4	9 $\pm$ 2	0.26	9 $\pm$ 3	7 $\pm$ 5	0.33
	F	11 $\pm$ 4	9 $\pm$ 4	0.26	10 $\pm$ 3	11 $\pm$ 3	0.3
	Total	10 $\pm$ 5	9 $\pm$ 4	0.33	10 $\pm$ 3	10 $\pm$ 4	0.37
40-49	M	10 $\pm$ 4	12 $\pm$ 8	0.28	17 $\pm$ 2	16 $\pm$ 3	0.07
	F	15 $\pm$ 4	15 $\pm$ 3	0.35	15 $\pm$ 5	16 $\pm$ 4	0.34
	Total	14 $\pm$ 4	15 $\pm$ 5	0.27	15 $\pm$ 4	16 $\pm$ 3	0.44
50-59	M	32.47 $\pm$ 6.32	19.31 $\pm$ 5.56	0.03 ^S	29.01 $\pm$ 5.44	17.56 $\pm$ 6.01	0.04 ^S
	F	28.86 $\pm$ 4.87	18.58 $\pm$ 5.24	0.01 ^S	25.8 $\pm$ 3.05	17.27 $\pm$ 3.19	0.002 ^{HS}
	Total	29.84 $\pm$ 5.24	18.78 $\pm$ 5.05	0.001 ^{HS}	26.68 $\pm$ 3.83	17.35 $\pm$ 3.79	0.004 ^{HS}
≥ 60	M	28.86 $\pm$ 2.38	15.63 $\pm$ 2.99	0.005 ^{HS}	24.03 $\pm$ 3.92	19.4 $\pm$ 2.37	0.03 ^S
	F	25.62 $\pm$ 6.84	17.49 $\pm$ 5.17	0.04 ^S	22.29 $\pm$ 4.5	12.12 $\pm$ 3.83	0.16
	Total	27.93 $\pm$ 3.75	16.16 $\pm$ 3.35	0.0001 ^{HS}	23.53 $\pm$ 3.78	17.32 $\pm$ 4.33	0.01 ^S

HS mean highly significant and S means significant.

clinical device with high repeatability of the recordings (15). The study extended from December 2022 to March 2024 to comprehend all possible timely changes in the mandible and bone structure and accommodate consecutive changes in the TMJ structure resulted from gaps filled with implants over decent period of time. The present study revealed a significant statistical change in ISS before and after implant for both sexes for left and side immediate side shift for age groups (50-59) and (≥ 60) only. The mean value of ISS before implant is more than normal range (0-2) mm. however, after implant this value reduced to be within the range. This change is mainly attributed to advancing in age and high number of missing teeth. Additionally, this study found there is a change in the RSCG for male and LSCG for female in age groups (50-59) and LSCG for male and RSCG for female in age group (≥ 60). Finally, the outcome of TCG, Bennett angle, revealed a significant statistical change before and after implant in age groups (50-59) and (≥ 60). The normal range is (5-20); however, the TCG values before implant for the aforementioned age groups was higher, but after implant the range reduced to be within normal. This is mainly related to the occluding surfaces. Due to large number of missing teeth in these age groups, larger angles resulted. After implants the occluding surfaces increased; consequently, Bennett angle reduced.

4. Conclusion

Implants play a vital role in TMJ articulation. It improves the movement of working and non-working condyle during opening and lateral movements. It also helps in opening and closing by removing extra stress on ligaments. This research presented a remarkable change based on student's T-test in TMJ variables (ISS, SCG, and TCG) in age groups (≥ 60) and (50-59) due to fact that these age groups had more than three implants. The measurements of (ISS, SCG, and TCG) variables changed from abnormal to normal ranges. This is also attributed to the fact that filling more gaps result in more balance to the TMJ movement. As this research was self-funded, the authors had to pay for the devices. Moreover, the sample size which matches inclusion criteria had to be collected from four tertiary hospitals. Furthermore, some measurements were time overhead since patients felt discomfort due to heavy body material used for Cadix II articulator resulted in gag reflex and accumulation of saliva. Also, Coordination with patients and implant surgeons across four hospitals was difficult and sometimes convoluted due to scheduling conflicts and availability conflicts. It is highly recommended to conduct same study on one or combination of the following factors: TMD patients, different skeletal classes such as II and III, anterior partial edentulous patients, and larger sample size.

Author Contributions

Conceptualization, Hasnaa Sharrad and Thaer Mohsin; Data curation, Muayed AL-Huseiny and Ahmed Alhuseiny; Formal analysis, Hasnaa Sharrad, Fawaz Al-Aswad and Thaer Mohsin; Funding acquisition, Hasnaa Sharrad; Investigation, Hasnaa Sharrad and Balsam Abdulhameed; Methodology, Hasnaa Sharrad and Fawaz Al-Aswad; Project administration, Hasnaa Sharrad and Thaer Mohsin; Resources, Hasnaa Sharrad, Fawaz Al-Aswad, Thaer Mohsin, Balsam Abdulhameed, Muayed AL-Huseiny and Ahmed Alhuseiny; Software, Muayed AL-Huseiny and Ahmed Alhuseiny; Supervision, Fawaz Al-Aswad; Validation, Hasnaa Sharrad, Fawaz Al-Aswad and Balsam Abdulhameed; Visualization, Muayed AL-Huseiny and Ahmed Alhuseiny; Writing – original draft, Hasnaa Sharrad; Writing – review & editing, Fawaz Al-Aswad, Thaer Mohsin, Balsam Abdulhameed, Muayed AL-Huseiny and Ahmed Alhuseiny.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the research ethics committee of the College of Dentistry, University of Baghdad (696722/01-12-2022).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Due to hospitals privacy rules, data is not applicable.

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Conflicts of Interest

The authors declare no conflicts of interest.

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