Clinical Outcomes of Implant Supported Mandibular Overdenture with Bar and Cantilevered Ball Bar Attachment: Crossover Study

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Abstract

This study aimed at assessing the maximum bite force (MBF) and the masticatory efficiency (ME) for mandibular implant overdenture (MIOD) assisted by anterior bar versus cantilevered ball (CB) bar.

Twenty completely-edentate patients received two inter-foraminal implants. The Patients were divided randomly and equally to ten patients received MIOD assisted with anterior bar, then after one year converted to CB bar for another one year. The rest of patients received MIOD assisted with CB bar then after one year replaced by anterior bar for another one year. MBF and ME were registered for each patient after three months of conventional denture insertion (T1), at insertion of MIOD (T2), after six months of MIOD insertion (T3) and after one year of MIOD insertion (T4).

For MBF, there was a significant increase in the recorded MBF within each group between at all intervals ($p < 0.001$). There was a significant difference between both groups at T2 and T3 ($p = 0.01$ and 0.02 respectively). For ME, There was a significant increase in the recorded ME within during wearing the MIOD with CB bar for all time intervals ($p < 0.001$). While at using anterior bar, there was a significant difference between T2, T3 and T4 only ($p < 0.001$).There was a significant difference between both groups at T2, T3, and T4 ($p < 0.001$).

Within the limitations of the study, patients wearing MIOD assisted by CB bar attachment design revealed superior MBF and ME comparing to anterior bar after one year clinical service.

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Introduction

Mandibular implant overdenture (MIOD) becomes the main line for treating the edentulous patients. Conventional mandibular denture wearers complain form looseness, instability and pain during function which can be assisted by dental implant. There is diversity during selection the suprastructres to anchor the denture to the implant as Locator, ball attachment, telescopic and bar attachment[1, 2].

Bar attachment was recorded to improve the biomechanics of the MIOs. The shape of the cross section of the bar allows or prohibit using bar as a fulcrum for denture rotation[3]. The bar may be customized or casted from readymade plastic pattern. The selection of the shape and method of bar construction are custom according to the state of the patient and the desired outcomes.

Anterior bar screwed to two inter-foraminal implants is the popular design with bar suprastructre. Lateral bars may be extended with two terminal implants. To overcome additional surgical procedures and cost of terminal implants, bar with cantilever is used to enhance MIOD biomechanics with less intervention. Furthermore, additional retention structures as Locator and ball can be used to augment the retention of bar[2, 4].

Maximum bite force (MBF) is a common method to evaluate the denture performance and adaptability within time[5]. The technique is used to follow adaptation of both complete denture and MIOD[6]. The measuring of MBF tools developed to be more handle by physician and acceptable

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by patient. Additionally, masticatory efficiency (ME) is an indicator for serviceability of restoration. Glucose-extract method is simple and reliable method to measure ME. This method based on measuring the released glucose from artificial food after certain chewing strokes[7].

The study aimed to evaluate the prognosis of MBF and the ME over a year of follow up for MIOD with anterior bar versus cantilevered-ball (CB) bar design as a treatment for mandibular edentulous ridge.

Materials and methods

Twenty completely edentulous patients were selected form outpatient clinic, Prosthodontic Department, Faculty of Dental Medicine, Al- Azhar University. The included patients were free from diseases hinder ability of patient to fulfill planned follow up. Patients with history of clenching, bruxism and/or TMJ disorders were excluded. All patients had available restorative space to receive the planned bar suprastructre; and Angel's class I maxillomandibular relationship verified by tentative jaw relation record. The elapsed time since last extraction was at least six months. All patients had sufficient bone quality and quantity pad in the mandibular inter-foraminal region verified by cone beam CT (CBCT) for placement of required implants. The final results and the achieved treatment procedures were verified to the regulation of ethical committee number (720/2292). The procedures of pre-surgical, surgical, pick-up and follow up and evaluation procedures were done.

II.1. Pre-surgical procedures

II.1.a. Construction of conventional complete denture

Primary and secondary maxillomandibualr impression were made; and jaw relation was registered and transferred to articulator by face-bow. Artificial teeth (Acrostone, Egypt) were set according to lingualized occlusion scheme[8]. After clinical try in, the denture was flasked, finished and polished. Patient received denture and followed up for one month to verify adaptation and occlusion.

II.1.b. Fabrication of implant-placement guide template

The mandibular denture was duplicated[9] and used during double scanned by CBCT with modified intaglio by adding gutta-percha and two round inserts in the polished surface opposing to canine areas[10]. Images were loaded into 3D image planning software (In2guide software by Cybermed) to virtually determine the suitable position of implants[11]. A mucosal supported stereolithographic surgical guide with metal sleeves and anchor pins was printed according implant planned sites (fig 1.a).

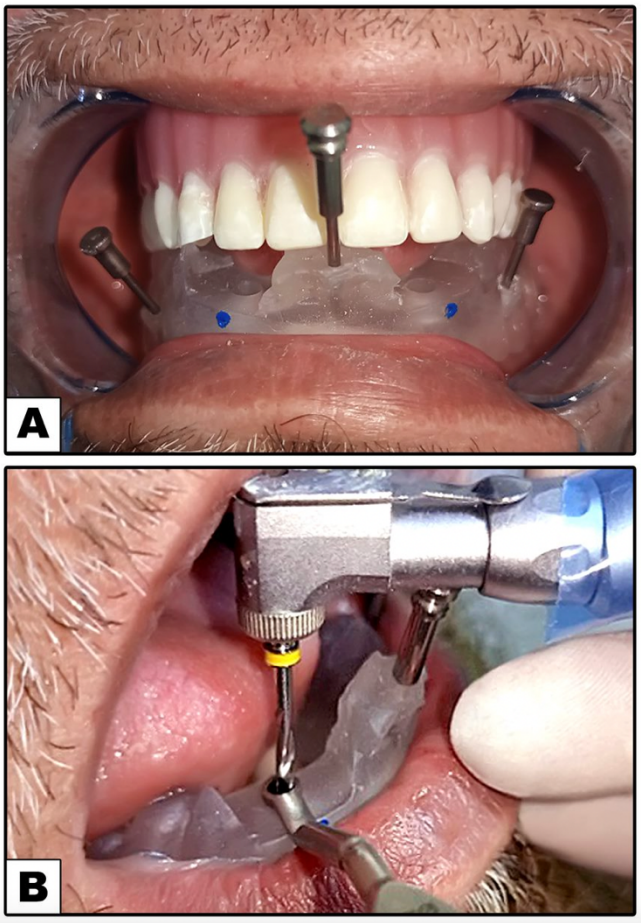

Figure 1. (a) Stereolithographic stent mounted on edentulous mandible, **(b)** drilling sequence for fixture mounting.

II.2. Surgical procedures

A dose of prophylactic antibiotic (Flumox, EPICO. Egypt) was administered one hour preoperatively. Under local anesthesia (Lignocaine 1.5% Alex. Co. Egypt), universal surgical kit (In2Guide Universal Kit, Cybermed Inc.) was used to perform full drilling sequence through the anchored stereolithographic stent (fig 1.b.). Each patient received two inter-foraminal fixtures (3.7x11.5 mm; Dentium, korea). The intaglio of the mandibular denture was relieved opposite to implants and filled with soft liner

(Promedica, Germany). Patient was instructed for home care and soft diet with frequent recall and follow up. After three months, healing abutments were mounted for two weeks with required modification of mandibular denture.

II.3. Distribution of patients

Patients were divided randomly and equally to ten patients received MIOD assisted with anterior bar, (fig 2.a), then after one year converted to CB bar, (fig 2.b), for another one year. The other ten patients received MIOD assisted with CB bar then after one year replaced by anterior bar for another one year. All patients received conventional maxillary denture opposite to the MIOD.

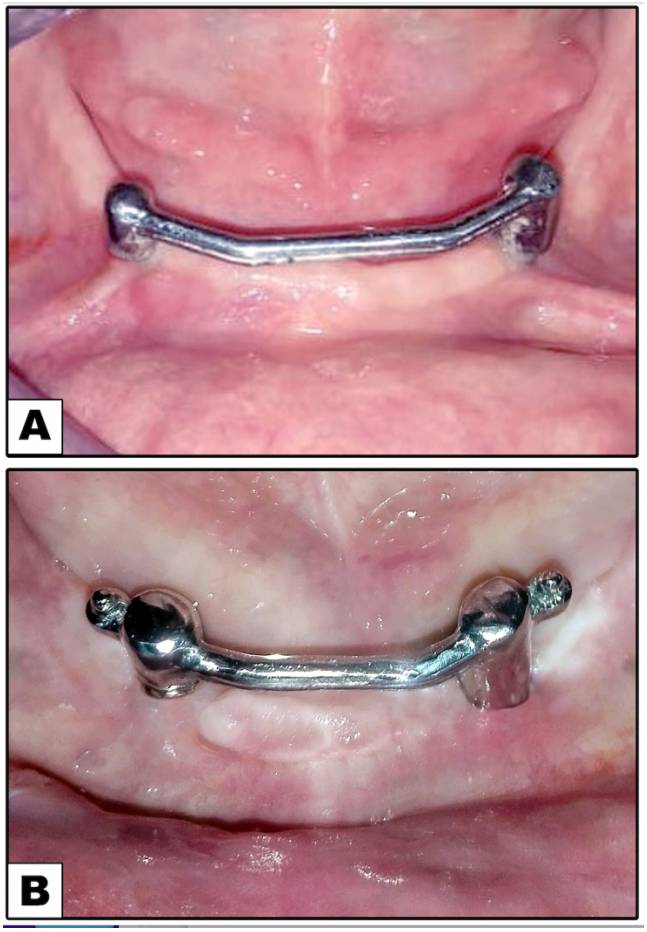

Figure 2. (a) Casted anterior bar between two interforminal implants, **(b)** casted cantilevered ball bar design.

II.4. Construction of attachment system

The analogue transfer was carried out for both implant with open tray technique[12].The implant analogues were attached to impression posts and the impression was poured with extra-hard stone. Two copings were screwed to the analogues. After cast scanning, both bars were designed on the virtually (fig 3 a and b). For CB bar, the cantilever part, 5mm, terminated with ball suprastructure (3mm diameter). The virtual design were milled to resin bar by CAM machine (Cerec inLab, Sirona, Germany). The bar was splitted and reassembled intraorally in case of any non-passive fit (Fig.4.a). The resin bar was checked intraorally before casting (Fig.4.b). Then, the passive fit resin bar was casted to metallic cobalt chromium bars[13].

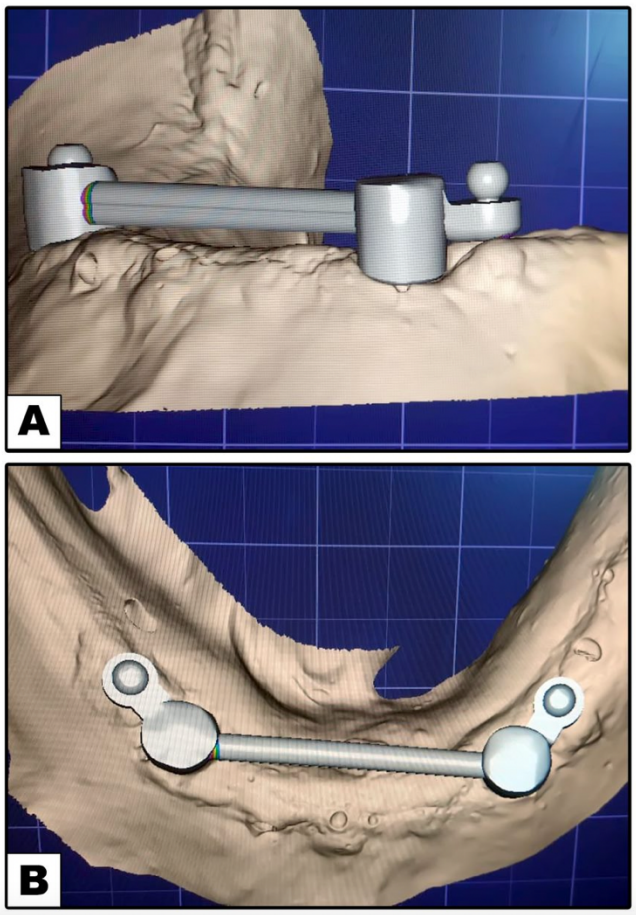

Figure 3. Virtual design of bar suprastructure **(a)** sagittal view, **(b)** top view.

II.5. Pick-up procedure

After checking passivity[14], of casted bar intraorally, all undercuts under the bar and its extension (in case of CB bar design) were blocked out with putty rubber base. Two plastics clips were mounted on the anterior segment of bar. Mandibular denture was modified to include suprastucture without rocking. The pick-up was done by adding auto-polymerized acrylic resin

(Acrostone, Egypt) to the modified intaglio of the denture and the clips were picked up under patient's occlusion. For CB bar design, silicon based soft liner (Promedica, Germany) was mixed according to manufacture and added to recess in fitting surface opposite to terminal ball attachments. The set of soft liner was done under the patient's occlusion force.

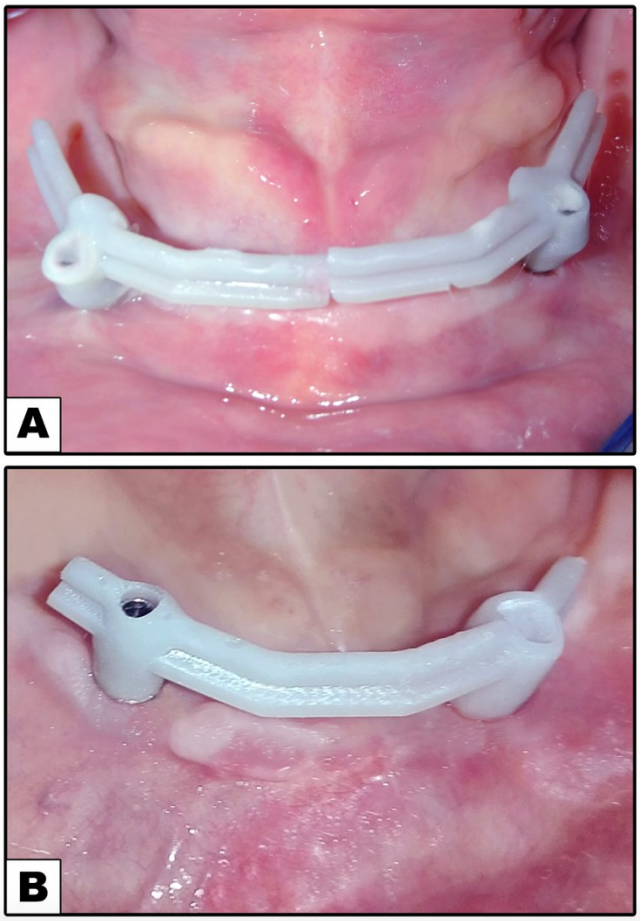

Figure 4. Resin bar intraorally **(a)** splitted from middle **(b)** after reassembly

II.6. MBF registration

MBF and ME were registered for each patient after three months of conventional denture insertion (T1), at insertion of MIOD (T2), after six months of MIOD insertion (T3) and after one year of MIOD insertion (T4). The force during maximum clenching was recorded with one bite force meter (GM10; Nagano Keiki, Tokyo, Japan) placed between opposing teeth at the first molar area. A cotton roll was placed in the opposite side preventing denture rotation. The mean of three repeated measures of MBF at left and right sides were calculated.

II.7. Assessment of ME

Glucose extraction method was used to objectively evaluate the ME according to Tanaka et al.[15]. Each patient was asked to chew readymade jelly specimen (10 mm height, 10 mm diameter and 5% glucose concentration) (Glucosensor Gummy, GC, Japan) for 20 seconds and expectorate into a cup with a plastic mesh filter. Then, patient rinsed mouth with 10 ml of water and spitted off into the same cup. Glucose concentration (mg/dl) in the filtrated cup was measured by Glucose Sensor Set (Glucosensor GS-II, GC, Japan). Measurements were repeated three times and mean was calculated.

Results

III.1. MBF evaluation with both bar designs

There was a significant increase in the recorded MBF within each subgroup of patients. During wearing the MIOD with anterior bar, the recorded MBE was 49.2, 101.6, 117.8 and 121.2 at T1, T2, T3 and T4; respectively ($p < 0.001$). At using CB bar design, the MBF was 46.5, 109.1, 124.6 and 126.4 for the same time intervals respectively. There was a significant difference between both groups at T2 and T3 ($p = 0.01$ and 0.02 respectively) (Table 1).

Period*	Anterior Bar		CB Bar		*t test*
	Mean**	SD	Mean	SD	*P*-value
T1	49.2^{aA}	11.3	46.5^{aA}	14.11	0.53
T2	101.6^{bB}	10.29	109.1^{b}	4.36	0.01
T3	117.8^{cC}	8.44	124.6^{c}	7.09	0.02
T4	121.2^{dD}	4.49	126.4^{dD}	9.46	0.09
Paired t test *P*-value	<0.001		<0.001		

Table 1. comparison of the recoded MBF between and within-subjects with different bar designs.

* T1: Three months after insertion of conventional denture, T2: at implant loading, T3: after 6 months of loading, T4: after 12 months of loading.

** Means not sharing any lowercase letter are significantly different by the paired t-test at the 5% level of significance.

**Means not sharing any uppercase letter are significantly different by the t-test at the 5% level of significance.

III.2. ME evaluation with both bar designs.

There was a significant increase in the recorded ME within each subgroup of patients. During wearing the MIOD with CB bar design, the recorded significant ME was 23.2, 27.1, 77.5 and

78.3 at T1, T2, T3 and T4; respectively (p <0.001). At using anterior bar, there was a significant difference between T2, T3 and T4 reading as 23.4, 72.7 and 76.2 respectively (p <0.001). Also, there was a significant difference between both groups at T2, T3, and T4 (p <0.01) (Table 2).

Period*	Anterior Bar		CB Bar		*t test*
	Mean**	SD	Mean	SD	*P*-value
T1	24.7^{aA}	5.3	23.2^{aA}	3.5	0.37
T2	23.4^{aB}	3.2	27.1^{b}	2.22	<0.01
T3	72.8^{bC}	5.1	77.5^{c}	8.3	
T4	76.2^{cD}	4.49	78.3^{d}	6.34	
Paired t test *P*-value	<0.001		<0.001		

Table 2. comparison of the recoded ME between and within-subjects with different bar designs.

* T1: Three months after insertion of conventional denture, T2: at implant loading, T3: after 6 months of loading, T4: after 12 months of loading.

** Means not sharing any lowercase letter are significantly different by the paired t-test at the 5% level of significance.

**Means not sharing any uppercase letter are significantly different by the t-test at the 5% level of significance

Discussion

Ability to perform mastication to improve the quality of life for edentulous patient depends on the proper biomechanics of the MIOD. The number and distribution of implants and the use of cantilevers may improve the overdenture serviceability[3]. Misch[16] suggested four implants as a minimum number to provide support for the distal cantilever up to 10 mm on each side to limit the risk of looseness of the screws and any other prosthetic complications. While, Mericske-Stern et al.[17] recommended up to 7 mm distal cantilever bar lengths on two implants supporting MOID. Total lengths of cantilever must be shorter than the central segment of the bar and terminate at the distal aspect of the first premolar[3]. Schneider and Kurtzman[18] used Locator attachment to augment the retention and support over custom bar with MIOD. Kim and colleges[4] used solitary attachment with double-sided bar MIOD. In this study, cantilevered ball attachment was used to assist MIOD. In this study, we aimed to avoid drawbacks of cantilevering by keeping it as short as possible, 5mm, and recompense the retention and support by terminal balls. Also, to minimize stresses on the terminal balls, soft liner is used as matrix for ball attachment[19]. Crossover study design was used to diminish the risk of confounding and bias in sampling[20].

According the result of this study, there was significant increase in the MBF registered with both bar designs. Rismanchian et al.[21] evaluated the MBF for individuals using conventional complete dentures versus others using MIOD recording The mean MBF values in the studied groups were respectively: 55.4 ± 14.31 N; and 119.84 ± 26.47 N. These results mimic our findings in this study. The exhibited forces steeply increased directly after implant loading and ascending during the observation period. This findings supported by Fontijn-Tekamp et al.[22] who elaborated a significant increase in MBF compared to complete denture wearers. The steep improving of MBF immediately after the placement of the implants may be explained not only by the distribution of forces on the mandible, but also on the reduced pain and discomfort of mucosal borne of new conventional denture[23, 24]. Other cause for the leap of MBF after insertion is due to psychological aspects as patients might feel encouraged to exert higher biting force when the denture is painless and supported by implant[5]. The continuous increase in MBF with MIOD have been confirmed after a long period of follow-up[25]. The within subgroup significance increase in MBF may be explained by reversing of atrophied pattern of masticatory muscle after losing of teeth. Edentulism accelerates atrophy of the jaw-closing muscles[26]. It was demonstrated that delivering MIOD could reverse this muscle waste in edentulous patients[23]. There was a significance between both bar designs in MBF, at T2 and T3 with the higher reading with the CB bar deign. This may be due to the better force distribution over the suprastructre with cantilevered arm. By distal extension of bar, the overdentures do not rotate freely during function which achieving more comfort and support during function[27]. Also, the cantilever increases the supporting pad for the overdenture which, in turn, enhance bite force. Higher stability and force distribution in the posterior extended bar may be the cause or the patient to increase the isometric muscle capacity to enhance bite force[28]. The absence of significance between both groups at T4 may be due to the accommodation of the patient after a year of using overdenture. The extended flange and adaptation of the fitting surface can enhance the MBF within time. This adaptation compensates the cantilever sharing in overdenture support to enhance MBF.

According our findings, there was a significant increase in ME through the follow up period. This explained by improvement stability and retention of the complete denture. Also, patients' feelings of comfort advances the ME[29,30].

The surprising result was the insignificant recorded ME between the conventional denture and MOID at time of insertion. This may be due to initial improper adaptation of MIOD by time. This may cause little control of artificial food during measurement[31]. Also, it may due to the texture of the test food which requires denture control to tear the food specimens which does not exist in the newly inserted denture. This is contradict with Roasa et al.[32] who stated approximately 50% in ME for overdenture wearers greater than those of the group rehabilitated with conventional complete dentures. On the other hand, there was significance at measuring ME before and at the time of loading the extended bar overdenture. Also, there was a significant increase in ME during the extended bar design. This may be due to the increased stability by the cantilever parts which allows more control during lateral movement required at comminution of food. The cantilever arm reduces posterior denture rotation and enhance tearing effect of teeth. Also, the enhanced retention with the terminal ball plays a role to keep the denture without dislodgement. This may overcome the stickiness of test food during measurement. This was supported with the finding of Koike et al.[19] who recorded significant retention when using soft liner as a matrix for ball attachment. In this study, the terminal ball/soft liner attachment was used in the same time with the clip on the anterior bar segment to enhance biomechanics. This is not contradict with Elsayad et al.[33] who recorded superior biomechanics with bar/clip attachment comparing to using soft liner with bar suprastructre.

There were some limitations during this study for example the short time of follow up and the small sample size. Also, the difference in retention with both bar designs might be a confounder. Thus, value of retention should be measured and in relation of MBF and ME.

Conclusions

Within the limitations of this study regarding sample size and short follow up period, patients wearing MIOD assisted by CB bar attachment design revealed superior MBF and ME comparing to anterior bar attachments after one year clinical service.

Declaration of Interest

The authors report no conflict of interest.

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