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RESEARCH ARTICLE

"EFFECT OF IMPLANT POSITION ON PROSTHESIS MOVEMENT OFMANDIBULAR TWO IMPLANT-SUPPORTED OVERDENTURE UNDERSIMULATING BITING FORCE - AN INVITRO STUDY"

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Abstract

Purpose: Purpose of this study to evaluate the effect of implant position on prosthesis movement of mandibular two implant-supported overdenture under simulating biting force.

Materials and methodology: 30 experimental overdentures (N=30) were made for an edentulous mandibular test model, which included artificial mucosa. Based on implant position, 30 samples overdentures were divided into three groups (n=10) (i.e., A and E, B and D,in between B and D). For this study, the ball and O-ring attachment system was used. 100 N vertical loads were used on the left first molar region, 55N on the left canine, and 40N on the mid-anterior area. The loading point's vertical displacement as well as the right distal edge's horizontal and vertical displacements were measured.A 1-way analysis of variance test was used to statistically analyse the displacement values with the implant position as a factor, ($p=.05$) was used to statistically analyze the values of the vertical and horizontal displacement at the distal edge of the overdenture.

Results: The mean horizontal displacement at right distal edge on incisor, canine and molar loading was highest in Group III with p value < 0.05. when compared in between groups with paired t tests there was no statistically significant difference on incisor loading between group II and Group III with p value >0.05. Mean vertical displacement at right distal edge on incisor loading was highest in group II and on canine and molar loading, it was highest in Group III.

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Conclusion: Change in implant position influences the displacement of implant supported overdenture.

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Introduction:-

While the rate of edentulism has been decreasing throughout the past three decades, the subsequent increase in the world population has resulted in increasing growth of total edentulous persons.Residual ridge resorption continues to be the primary complication of edentulism[3]. To minimize loss of residual ridge, exemplary complete denture therapy and routine recall systems should be the goal of treatment[2].

Complete dentures are the mainstay of treatment for the vast majority of edentulous patients, most of them are satisfied, but others are unable to adapt. With increasing evidence that implant retained or supported prosthesis is superior to conventional dentures in many ways, patients can hope for well-functioning complete dentures[3].However, the perceived masticatory capacity of denture wearers is negatively impacted by the rotational movement of the implant-supported overdenture. Therefore, it is necessary to prevent rotational movement to improve the quality of life for edentulism sufferers.[8]

According to Mcgill consensus 2002 statement that an overdenture retained with two implants should be the standard of treatment for patients with edentulous mandibles. Henceforth, when the objective is to make implant-supported overdentures a more affordable option in cases of low bone volume and ridge form availability, a two implant-supported overdenture treatment option becomes indispensable.[11]

Many studies have found that resorption of anterior mandibular bone under implant overdenture is as low as 0.5mm over five years. In addition to that some studies observed that load-related bone remodelling in the anterior mandible is caused by increased function with implants.[9]

The optimal density and height of bone for supporting implant are located between the mental foramina of anterior loops of the mandibular canal in the anterior mandible. The available bone of the anterior mandible is divided into five equal columns of bone serving as potential implant sites. These sites are labelled A, B, C, D & E. (Fig:1). All implant sites are designed at the time of surgery regardless of the treatment option beingexecuted.[6]

Oda et al.,(2017)[8] evaluated the denture movement of mandibular implant-supported overdentures anchored by different numbers of implants and concluded that two implant-supported overdentures increased the rotation of the denture base more than one or three implant-supported overdenture.Zhang et al.,(2019)[12] compared prosthesis movement of mandibular implant-supported overdenture based on implant number and concluded that implant number effect the movement of implant retained overdenture.Majnu et al.,(2013)[4] compared three different attachment systems for denture mobility and load transfer characteristics of implants. They concluded that ball attachments provided the best denture stability and the least load transfer to the implant.

Naert I et al., (2005)[7]conducted a 10-year randomized clinical trial on the prosthesis aspect and patient satisfaction on two implants retained overdenture supported by three different attachment systems and concluded that ball retained overdentures showed at ten years the highest retention force compared to bar and magnet attachment. Patient satisfaction and comfort were more for ball retained overdenture than bar and magnet retained overdenture. To date, many studies included the area of interest in implant number and type of attachment in the prosthesis movement of implant-supported overdentures. Studies were obscure regarding the effect of implant position on the prosthesis movement of mandibular two implant-supported overdenture.The present in vitro study evaluated the effect of implant position on the prosthesis movement of mandibular two implant-supported overdenture under simulating biting force.

Materials and Methodology:-

An edentulous mandibular model (NAVADHA ZX, india) was selected. Implant positions were marked on the model based on the study criteria, i.e., A and E position, B and D position, in between B and D position. Four implants (ADIN ISPS1142D TOUAREG-S, Israel, 3.75 × 11.5 mm) at A, E, B and D positions and two implants in between B and D positions were drilled into the edentulous mandibular model (Fig:1). An edentulous mandibular cast was fabricated by replicating the mandibular model over which mandibular overdenture was fabricated using the conventional compression moulding method. The obtained denture was used to create a polysiloxane putty mould(DENTSPLY AQUASIL soft putty) tofabricate 30 standardized dentures (Fig:2).Denture teeth were placed into the mould, followed by injection of molten base plate wax. A total of 30 wax dentures were fabricated, then made into complete mandibular dentures according to a series of processing including flasking, dewaxing, and curing (Fig 3).

A ball and O-ring attachment system (ADIN DENTAL IMPLANT SYSTEMS LTD) was selected. A pair of the ball and O-ring attachments (height 4mm) with metal housings were secured to 20 Ncm at A and E, B and D, in between B and D positions (Fig4),(Fig5) and (Fig6). Additionally, artificial saliva (Wet mouth, ICPA health product) was added to replicate the oral environment. 0.9 ml of artificial salivawas used before each test as suggested by previous studies.

A universal testing device was used to perform loading tests. 40 N was applied to the incisors, 55 N to the left canine, and 100 N to the left first molar, resulting in three different loading situations. A computer attached to the machine served as the loading process's controller, allowing loading speed, force, and duration to be predetermined. A 5 mm diameter acrylic ball was applied at a speed of 0.5mm/min until the force reached 40N for incisor loading (Fig7), 55N for loading canine (Fig8) and 100N for molar loading (Fig9) was then maintained for 15 seconds. During this time, the computer recorded vertical movement at the loading point, while a movement sensor was used to measure the horizontal and vertical movement of the overdenture at the right distal edge. This loading test was performed on each denture and movement was measured accordingly.The data were subjected to statistical analysis using IBM SPSS Statistical Package for Social Science Version 21. Mean and SD of the Horizontal and Vertical Movements were obtained for Incisor, Canine and Molar. To compare between Groups, ANOVA with Post Hoc Tukey's was applied. All the statistical tests were applied, keeping a confidence interval at 95%, and ($p<0.05$) were considered statistically significant.

Fig 1:- Implants placed at A and E, B and D, and in between B and D.

Fig 2:- Wax denture was duplicated using putty siloxane impression material.

Fig 3: -Mandibular complete overdentures.

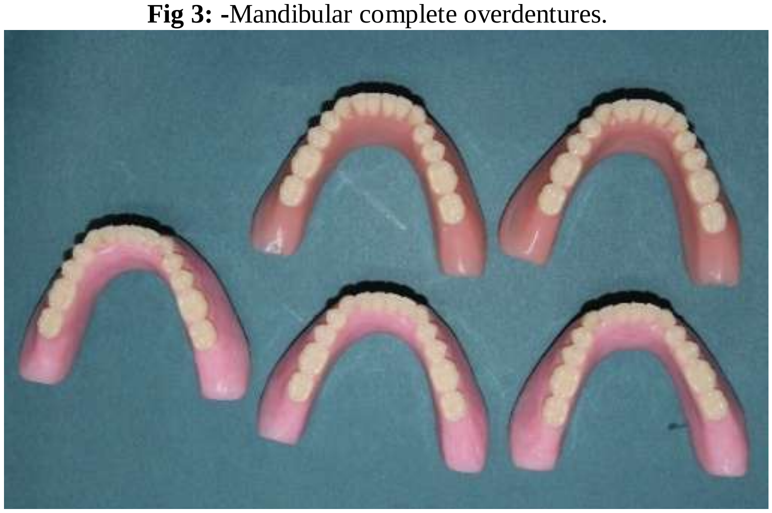


Fig 4: -Ball attachments secured at A and E position.

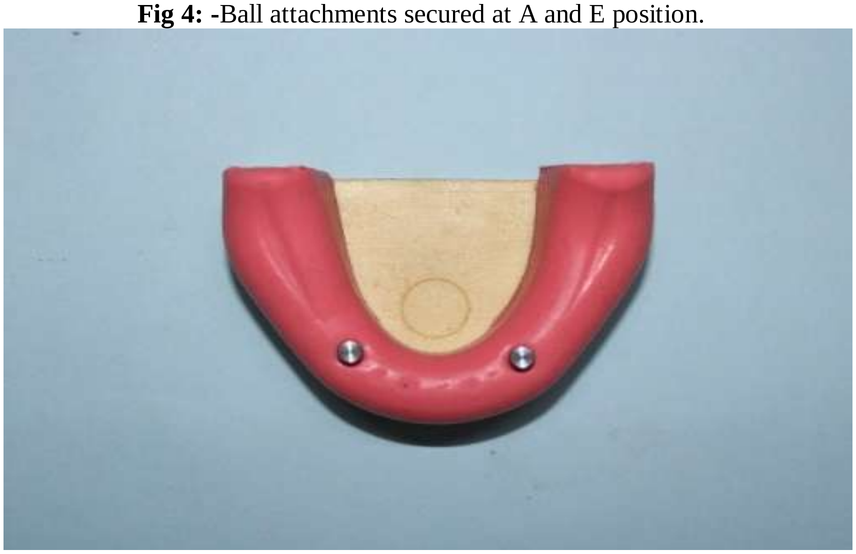


Fig 5:- Ball attachments secured at B and D positions.

Fig 6:- Ball attachments secured in between B and D positions.

Fig:7:- Molar loading with 100N and displacement of denture is detected with movement sensor

Fig: 8:- Loading of canine with 55N and displacement is detected with movement sensor.

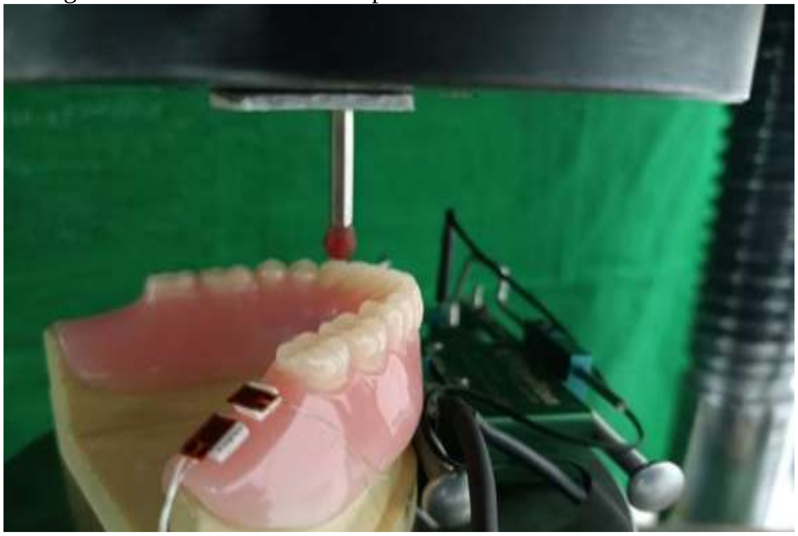
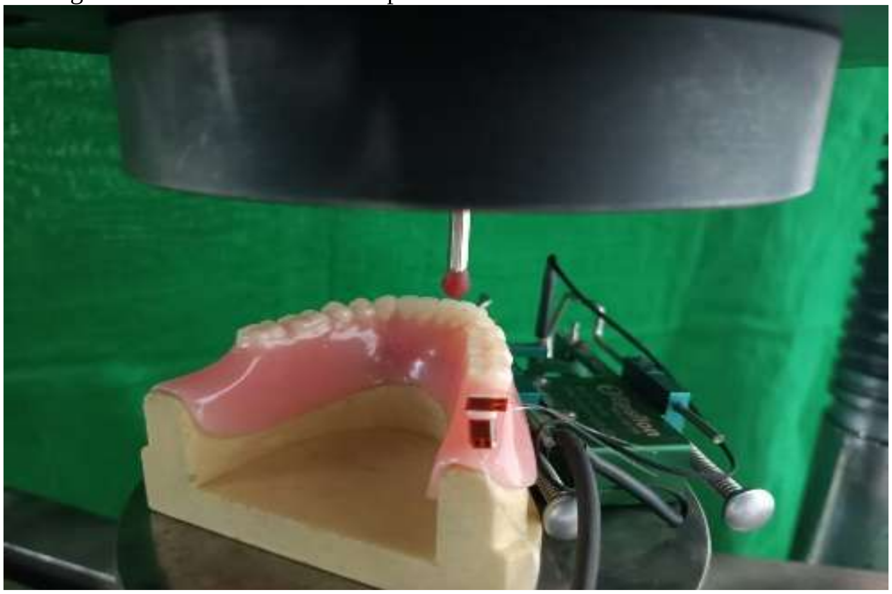


Fig:9:- Loading of incisor with 40 N and displacement of denture is detected withmovementsensor

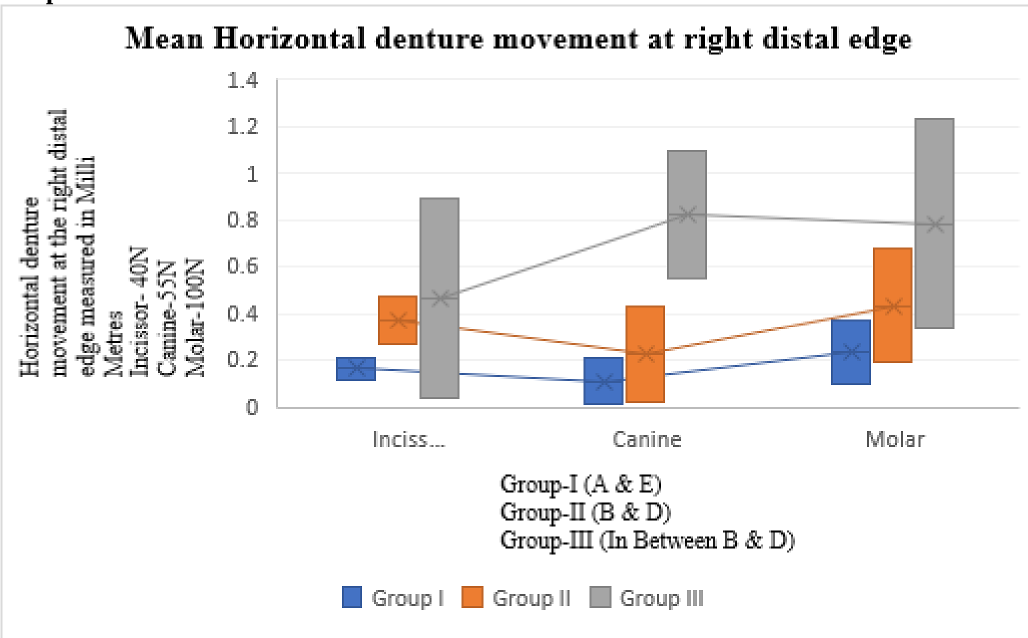


Results: -

Table 1 shows that the mean horizontal displacement at the right distal edge on incisor, canine and molar loading was highest in Group III with p value < 0.05.(Graph1) when compared in between groups with paired t tests there was no statistically significant difference on incisor loading between group II and Group III with p value >0.05.

Table 2 shows that the mean vertical displacement at right distal edge on incisor loading was highest in group II and on canine and molar loading it was highest in Group III (Graph 2). When compared in between groups with paired t test there was a statistically significant difference between all groups with p value <0.05.

Graph 1:-



Graph 2:-

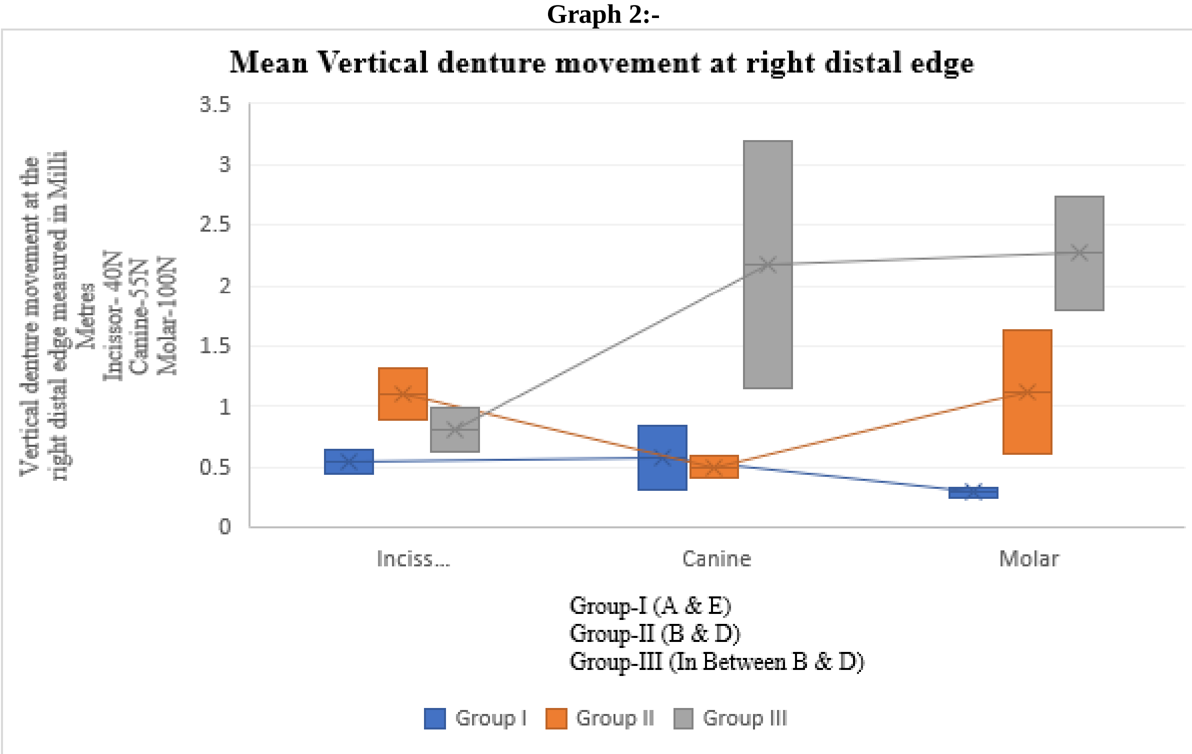


Table1:- Mean horizontal denture movementdisplacement at right distal edge.Mean horizontal denture displacement at right distal edge.

Loading point	Group I(A and E)	Group II (B and D)	GroupIII(in between B and D)	P value
Incisor (40N)	.1650 ± .03028	.3580 ±.07162	.4070 ± .27564	Group I vs Group II, Group I and Group III (p<0.05) Group II

				vs Group III (p> 0.05).
Canine (55N)	.1020 ± .06408	.2030 ± .13141	.7800 ± .17751	Group I vs Group II, Group I and Group III Group II vs Group III (p<0.05).
Molar (100N)	.2350+.09083	.4180+ .17028	.7330+.31609	Group I vs Group II(p>0.05), Group I vs Group III and Group II vs Group III (p<0.05).

Table 2:- Mean vertical denture movement displacement at right distal edge.

Loading point	Group I (A and E)	Group II (B and D)	GroupIII (in between B and D)	P value
Incisor (40N)	.5240 ± .07137	1.0770 ± .14591	.8090 ± .12161	Group I vs Group II, Group I and Group III Group II vs Group III (p<0.05).
Canine (55N)	.5800 ± .18166	.4910 ± .06173	2.0240 ± .72308	Group I vs Group II, Group I and Group III Group II vs Group III (p<0.05).
Molar (100N)	2950 ± .03028	1.0820 ± .36027	2.2320 ± .31605	Group I vs Group II, Group I and Group III Group II vs Group III (p<0.05).

Discussion:-

The Null hypothesis of the study is no effect of implant position on the prosthesis movement of mandibular two implant-supported overdenture. Results of this study have rejected the null hypothesis and found the alternate hypothesis as there is an effect of implant position on prosthesis movement of mandibular implant-retained overdenture.

Mandibular overdentures move in six complex ways, i.e., occlusal, gingival, mesial, distal, facial, and lingual, when in situ in an oral environment.

With the exception of vertical movement on Incisor loading, which shows the highest for Group II (B and D), this study demonstrates that the mean horizontal and vertical movement at the right distal edge of the overdenture was higher in Group III (in between B and D) compared to Group I(A and E) and Group II(B and D) on Incisor, Canine, and Molar loading. A statistically significant difference between the three groups (p<.05) indicates that the mobility of the implant-supported overdenture's prosthesis is influenced by the position of the implant.Considering the biomechanical principles of removable partial dentures, Levers are classified according to the relative location of the fulcrum and effort and resistance arm. Class I lever contains a fulcrum between two forces, a class II lever contains resistance in the middle between the force and fulcrum, and a class III lever contains the effort between resistance and fulcrum[1](Fig :10).

Class I lever:

Class II lever:

Class III Lever:

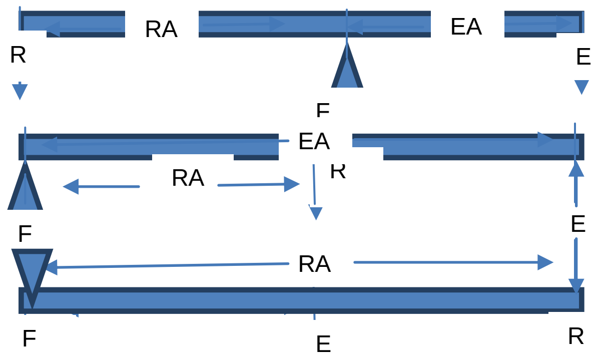


Fig 10:- Components of a class I,II, and III lever system with the implant and attachment serving as the resistance/fulcrum point.

Assuming the example of an implant-retained overdenture prosthesis intimately fitting the soft tissue support, the fulcrum is the anterior alveolar ridge, the resistance is the attachment system, and the effort is the posterior dislodging force lifting the denture base away from the ridge. Analyzing an example where implant location is anterior, such as in the incisor region. The fulcrum and resistance point would be coincident, thus making for a short resistance arm. Moving the implant location distally, the resistance arm is lengthened.

In Group I, the position of the implant is at A and E, which is far posterior than group II and group III explaining that the resistance arm is lengthened in Group I resulting in more mechanical advantage compared to other groups. Therefore, Anteroposterior displacement of the denture would be less when the implant location is paced far posteriorly.Schreger et al., (2014)[10] studied the comparison of retention and stability of mandibular implant-retained overdenture based on the implant location and found that an increase in interabutment distance would increase denture stability and anteroposterior posterior stability increased with distal implant location, which is equivalent with the present study.Michelinakis et al., (2006)[5] studied the influence of inter-implant distance and attachment type on the retention of the mandibular two-implant retained dentures and found that an increase in interimplant distance would increase the retention of mandibular two-implant overdenture, especially overdenture anchorage by ball attachments.

On incisor loading, the mean vertical movement at the right distal edge was highest for Group II (B and D). This might be predicted as the load on the incisor for Group III (in between B and D) shows lesser vertical movement than Group II (B and D) due to resistance offered by the attachments placed between B and D whereas Group II(B and D) shows higher than Group I(A and E) due to shorter resistance arm compared to Group I as described by Avant et al.[1]Up on incisor loading When comparing in between groups, Group II and Group III shows no statistically significant difference indicating that implant position at B and D and in between B and D shows the least difference in horizontal denture movement on incisor loading.

In light of the above, considering all factors, when the patient chews food with an incisal edge, there would be more posterior dislodgement. When chewing on one side, the denture would rotate mediolaterally. To minimize these dislodging forces placing an implant more posteriorly increases inter-implant distance and uniform force distribution, which would increase stability and retention of the mandibular two overdentures.This study considered only ball and o-ring attachment systems on prosthesis movement, which cannot apply to other attachment systems.Because the clinical reality of the implant overdenture is far more complex than a laboratory setting can duplicate, the testing performed is constrained by certain conditions and procedures and does not imitate clinical situations.The findings of this study do not account for attachment wear and resiliency.

Conclusion:-

Within the limitations of this invitro study, the following conclusions were made:

Change in implant position affects the prosthesis movement of mandibular two implant-supported overdenture.With more distant implant placement, a simulated overdenture prosthesis' anteroposterior stability and horizontal stability increased.With increased inter-implant distance, the overdenture's rotating movement under simulating biting force reduces.There is no discernible difference in the horizontal displacement up on incisor loading among B and D and in between B and D positions.

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