A STUDY TO COMPARE AND ADJUST THE NUMBER OF OCCLUSAL CONTACTS IN A PROVISIONAL RESTORATION IN CENTRIC OCCLUSION USING A VIRTUAL ARTICULATOR AND FUNCTIONALLY GENERATED PATH TECHNIQUE.

Abstract:-**Aim and Objective:** The present study was done with the aim to compare and adjust the number of occlusal contacts of provisional restoration in centric occlusion using a virtual articulator and functionally generated path technique(FGP). objectives of this study were;1) To assess the number of occlusal contacts of a provisional restoration prepared on a virtual articulator and using FGP technique separately, 2)To compare the number of occlusal contacts of provisional crown fabricated by using virtual articulator and FGP technique. 3)To compare the number of adjustments required to equalise the contacts in provisional restoration made by using virtual articulator and FGP technique in centric occlusion.**Materials and Methods:** The study involved Ten patients requiring complete veneers on lower first molars, were selected and given two provisional restorations one fabricated using functionally generated pathway and the other using a virtual articulator. **Results:** The mean number of occlusal contacts in FGP at centric after the first four adjustments were 3.9, 5.4, 5.0, 6.6 respectively. The mean number of occlusal contacts in the prosthesis fabricated using virtual articulator at centric after the first four adjustments were 7.0, 9.7, 9.2, 10 respectively. The mean number of occlusal corrections made in FGP at centric was 6.4 and the mean value of occlusal corrections in virtual articulator at centric was 2.7. The mean value of number of occlusal contacts in prosthesis fabricated using FGP technique at eccentric after the first two adjustments were 4.6 and 4.7 respectively where as in the prosthesis fabricated using virtual articulator was 4.4 and 5.3 respectively. The number of occlusal contacts were marginally more in the prosthesis fabricated using virtual articulator than from the prosthesis fabricated using FGP. The mean value of occlusal corrections in FGP at eccentric was 2.7 whereas the mean value of number of occlusal corrections in a prosthesis using a virtual articulator was 1.9. The number of occlusal adjustments in virtual articulator was less in both centric and eccentric than that of FGP proposed by Meyers.**Conclusion:** The present study shows that virtual articulator has been deemed better in terms of both patient compliance as well as operator's ease in delivering of the prosthesis.

Keywords:- occlusal contacts, virtual articulator, FGP

Introduction:-

One of the most common prosthodontic treatments rendered to patients is placement of crown. As the lower first molar is the first posterior teeth to erupt in the oral cavity (i.e. 6 years), it is more prone to caries and a root canal treatment might be necessarily followed by placement of a crown. The success of a crown is determined by many factors, out of which one such factor being occlusion. Functionally Generated Path technique is one such method to record the dynamic occlusion which was first proposed by Meyers and was termed as chew in technique. In 1933, Meyer described techniques that allowed the dentists to use the patient's mandibular movements to carve an occlusal surface. Functional Generated path is determination of the harmonious relationship between the occlusal path (the functional occlusal path) and the condylar paths at a given vertical dimension [1,2]. Articulators are mechanical instrument that represents the temporomandibular joints and jaws, to which maxillary and mandibular casts may be attached to simulate some or all mandibular movements [1]. There are many types of articulators used in dentistry such as mean value articulator, semi adjustable articulator and fully adjustable articulators. One of the recent advances in articulators are virtual articulators. Virtual reality refers to "immersive, interactive, multi-sensory, viewer centered, three-dimensional (3D) computer generated environments and the combination of technologies required to build these environments". In essence, virtual reality is a clone of physical reality creating a virtual environment to replace the real-world environment. Virtual articulators use virtual reality to simulate jaw movements.[4] The basic system of the virtual articulator generates an animation of the movements of the mandible based on the input data, and calculates the points of occlusion, which in turn are shown on-screen by means of some type of code. [3,4,5,6]

Ideally, the virtual articulator is equipped with a device for registering the specific mandibular movements of a given patient (such as the JMA), and can integrate the movements recorded in the animation.

There are two types of virtual articulators namely -Completely adjustable and mathematically simulated.[7] The virtual articulator requires digital 3D representations of the jaws and patient specific data on jaw movements and then simulates jaw movements and provides a dynamic visualization of the occlusal contacts. The most precise occlusal surface reproduction can be accomplished by using virtual articulators with CAD/CAM systems. The virtual articulator has been compared with the mechanical articulator in orthognathic surgery, to create ideal maxillary position and for making surgical splints and concluding that the virtual method is more precise than the conventional approach.[8,9]

The purpose of this study is to make a detailed comparative evaluation of occlusal points and occlusal adjustments in functionally generated path technique and virtual articulators.

AIM AND OBJECTIVES:-

The present study was planned with the aim to compare and adjust the number of occlusal contacts in a provisional restoration in centric occlusion using a virtual articulator and functionally generated path technique. objectives of this study were; ;1) To assess the number of occlusal contacts of a provisional restoration prepared on a virtual articulator and using FGP technique separately, 2)To compare the number of occlusal contacts of provisional crown fabricated by using virtual articulator and FGP technique. 3)To compare the number of adjustments required to equalise the contacts in provisional restoration made by using virtual articulator and FGP technique in centric occlusion.

MATERIALS AND METHODOLOGY:-

The present study was conducted in the Department of Prosthodontics, Crown and Bridges,Babu Banarasi Das College of Dental Sciences, BBD University, Faizabad Road, Lucknow, India. The study was approved by the institution ethical committee and the code allotted to the study was **IEC CODE 28.** In this study written consent was taken from all patient involved in this study.

DATA COLLECTION:-

Ten patients requiring crowns for lower first molars were selected for the study sample as per the inclusion and exclusion criterias. All patients were given two provisional restorations one fabricated using functionally generated pathway and the other using a virtual articulator.

MATERIALS:-Materials required are;Mouth mirror(GDC), Tweezers(GDC), Explorer(GDC), Airotor(NSK), Round end tapered bur(Mani), Torpedo diamond bur(Mani), Tapered fissure bur (171L) (Mani), Milling machine (IMS I core), Irreversible hydrocolloid impression material(Algitex), Dental stone plaster Type III(Kalabhai), Medit- 3D scanner, EXOCAD software, Semi adjustable articulator(Bio-Art), Self-curing acrylic resin(PYRAX), Pattern resin(GC), Tooth coloured self-cure acrylic resin(DPI), GDC Articulating Paper Holder, Articulating Paper(Bausch), Laboratory micromotor, Straight hand piece, Round bur(BR-31). (figure1-9)

METHOD:-The patients included in this study are; requiring a crown on 1st mandibular molar with unrestored antagonistic dentition, Patients with Class 1 molar relation, Age group- 18-50 years, good periodontal health and good oral hygiene. The patients excluded in this study are having; Premature contacts, TMJ disorders, Supra eruption of antagonistic teeth, Allergic to material being used, Partially edentulous, Peri-apical pathology. An elastomeric impression was made using a single stage double mix technique prior to the

treatment which would be used as an index for fabrication of a temporary crown using indirect method. The molar was prepared using round end tapered bur, torpedo diamond bur and tapered fissure bur (171L). Two impressions were made and poured using dental stone type III.

Virtual articulator method:- One set of casts was scanned using 3D scanner (MEDIT) and virtual casts were obtained. These casts were mounted on the virtual articulator with condylar guidance as 30 degrees and incisal guidance as 15 degrees. CAD designing of the provisional restoration was done using the EXOCAD software. The provisional restoration was milled on a milling machine (ImesIcore) on a Poly methyl metharcrylate block. The final finishing and polishing of the provisional restorationwere done. The CAD milled provisional restoration was seated in the patient's mouth without adjusting the occlusal surface. Articulating paper of 10 µm thickness was used to check the occlusal contacts in the patient's mouth.

FGP technique: -The second set of casts was taken and a customized closed-mouth impression tray was made on the cast using a self-curing acrylic resin. The tray was designed to include and adapt on the adjacent teeth for stabilization and to have a flat top as an FGP table. After adjusting the custom tray using a self-curing acrylic resin, the tray was verified to be stable, to be smoothly inserted and removed, and not to interfere in centric and eccentric mandibular movements and then the next step was performed. A self-curing acrylic resin (Pattern Resin,GC) was put on the FGP table, and the custom tray was placed on the prepared teeth. FGP was engraved into the resin as it was in the plastic stage by letting the patient move their mandible in protrusive, retrusive and lateral directions. The custom tray with engraved pattern resin of the FGP is removed from the patient's mouth Indexing of the pattern resin is done and both the casts are mounted on a semi adjustable articulator. Provisional restoration is fabricated using tooth colored acrylic resin using the index as a guide. The resultant provisional restoration is trimmed, finished and polished, and then was seated on the prepared tooth. The articulating paper is then used to check the occlusal contacts on the restoration. First the patient was asked to occlude in centric occlusion and the number of contacts on the provisional restoration was noted and the number of adjustments were done till there were uniform and no premature contacts exist.

Evaluation: To evaluate the occlusal contacts of each of the crowns two factors were taken into consideration i.e a reference tooth and patient compliance. The reference tooth that was designated was mandibular second molar that would have to show the same contact intensity with its opposing tooth both without the crown in place on the first molar and with the crown in place. Only once verified as fully seated, was the time taken to achieve a correct occlusal

contact relationship. The number of occlusal adjustments were noted for both the provisional prosthesis fabricated by virtual articulator and functionally generated pathway technique. After noting the number of contacts in centric relation the patient is asked to make eccentric movements and the eccentric contacts were marked using the articulating paper and the number of contacts were noted. During lateral movement of the mandible, on the working side there would be contacts on the outer inclines of the buccal cusp of mandibular first molar and inner inclines of the lingual cusp of the mandibular first molar. On the other hand in non-working side contact would be present on the inner slope of buccal cusp of mandibular first molar. The necessary adjustments were done till there were uniform and no premature contacts.The resultant occlusal points were analysed on both the provisional restorations i.e the former using virtual articulator and the latter using the functionally generated pathway technique.[figure 10-14]

All reading of occlusal contacts and occlusal adjustments were tabulated and sent for statistical analysis.

Figure-1 Diagnostics and airotor

Figure-2 Articulating paper

Figure-3 Recording of FGP

Figure-4 FGP after recording

Figure-5 Indexing of FGP

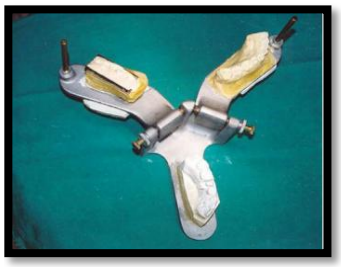


Figure-6 Twin bite

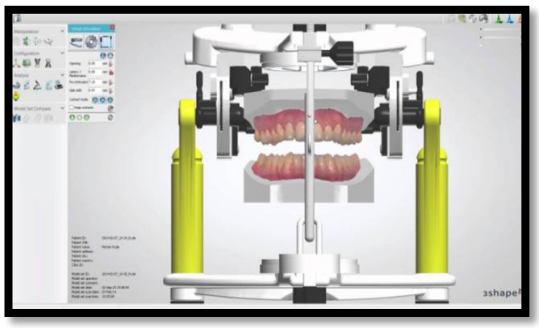


Figure-7 Virtual articulator

Figure-8 Lab scanner

Figure-9 CAD/CAM machine

Figure-10 checking occlusion

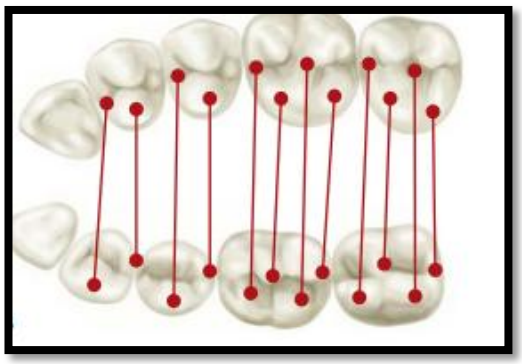


Figure-11 Normal occlusal contacts in centric

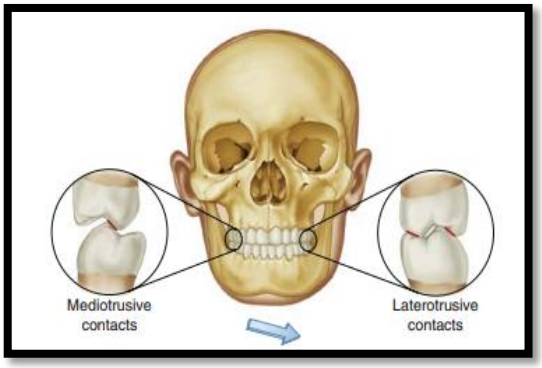


Figure-12 Normal occlusal contacts in eccentric

Figure-13 Occlusal contacts in centric

Figure-14 Adjusting occlusal contacts

RESULTS:- Comparison of occlusal contacts (centric and eecentric) after adjustments by Wilcoxon test for FGP and virtual articulator [Table 1,2 and Graph 1,2].

Comparison of occlusal adjustments (centric and eecentric) by Wilcoxon test for FGP and virtual articulator [Table 3,4 and Graph 3,4].

Table:1

Comparison of number of contacts (Centric)					
		Mean	N	Std. Deviation	P value
Adjustment 1	FGP	3.900	10	.9944	0.005, S
	VA	7.300	10	2.0575	
Adjustment 2	FGP	5.400	10	1.5776	0.007, S
	VA	9.700	10	3.0203	
Adjustment 3	FGP	5.000	4	1.4142	0.068, NS
	VA	9.250	4	1.7078	
Adjustment 4	FGP	6.667	3	1.1547	0.109, NS
	VA	10.000	3	2.6458	

Wilcoxon test

Graph 1

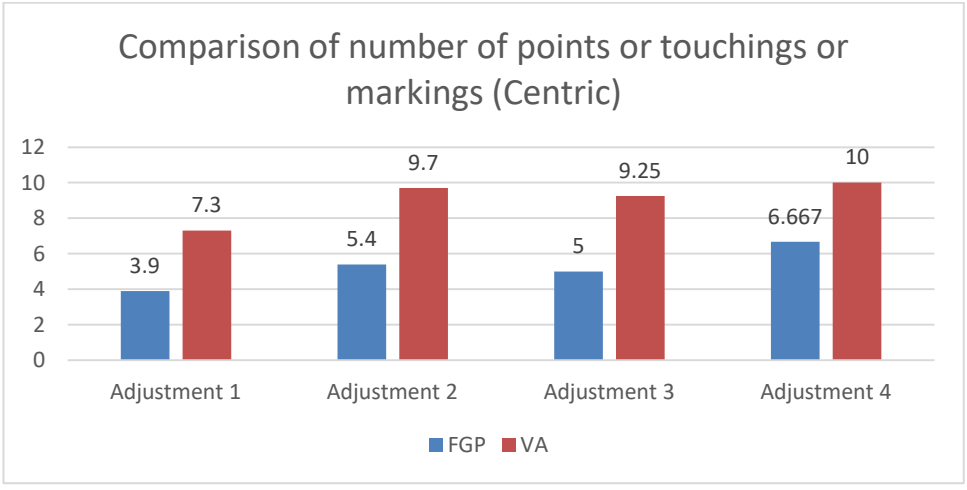


Table 2

Comparison of number of contacts (Eccentric)					
		Mean	N	Std. Deviation	P value
Adjustment 1	FGP	4.600	10	1.7764	0.722, NS
	VA	4.400	10	2.4129	
Adjustment 2	FGP	4.700	10	1.5670	0.327, NS
	VA	5.300	10	1.4181	

Wilcoxon test

After 1st& 2nd adjustment, mean number of markings did not differ significantly among FGP & VA group.

GRAPH;-2

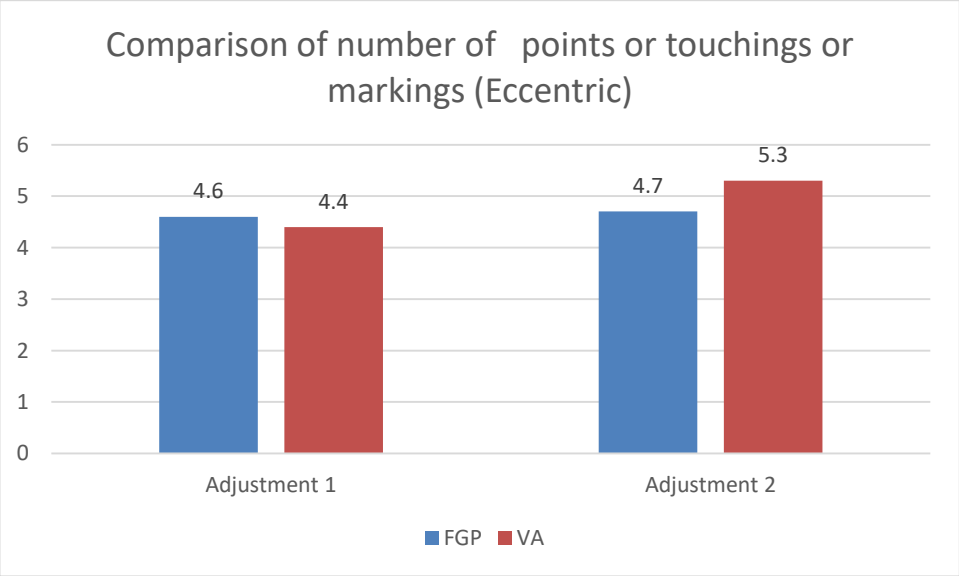


Table 3:

Comparison of adjustments in centric & eccentric				
	Mean	N	Std. Deviation	P value

FGP	Centric	6.400	10	1.7764	0.004, S
	Eccentric	2.800	10	1.1353	
VA	Centric	2.700	10	1.2517	0.038, S
	Eccentric	1.900	10	.5676	

Wilcoxon test

Mean number of adjustments done were significantly high among Centric type among both FGP & VA groups.

Graph 3:

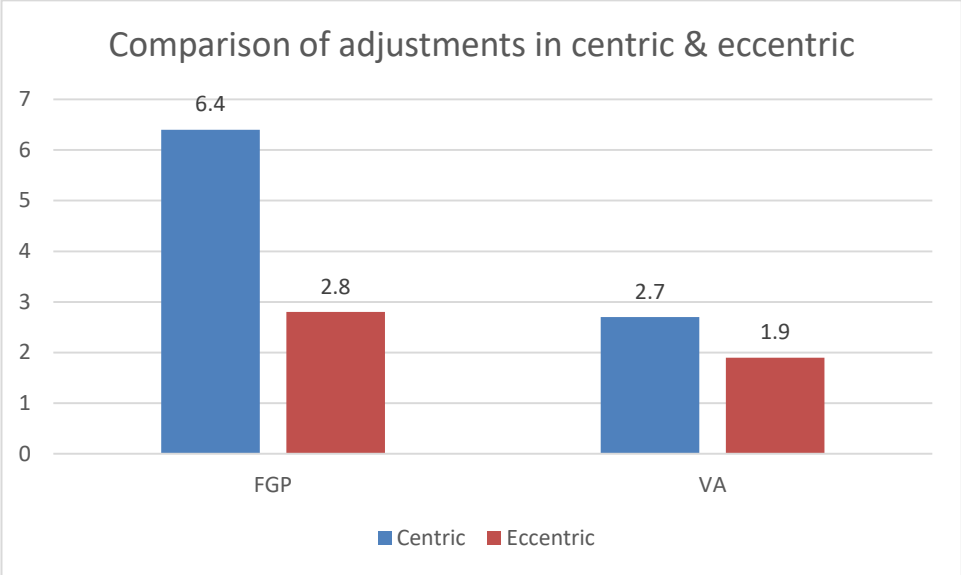


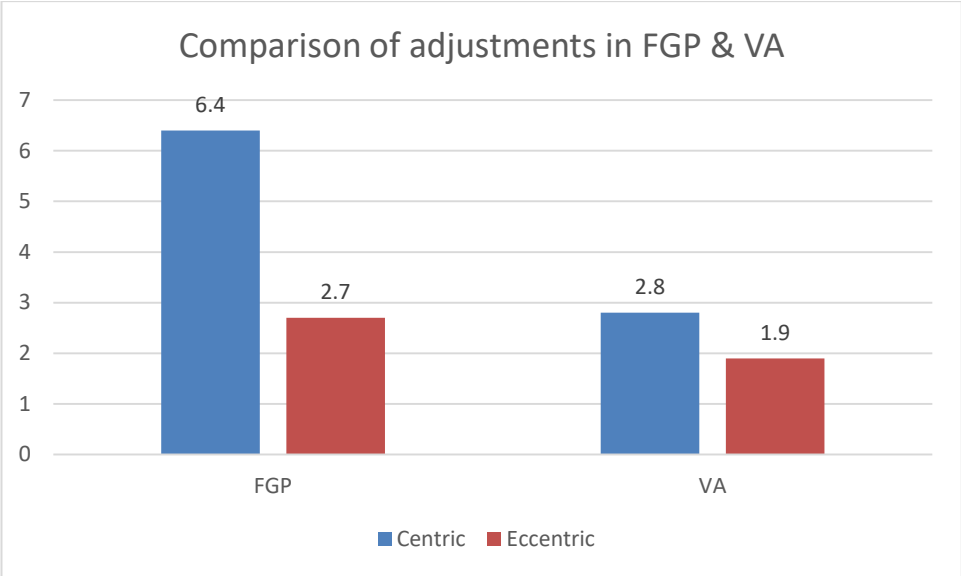
Table 4:

Comparison of adjustments in FGP & VA					
		Mean	N	Std. Deviation	P value
Centric	FGP	6.400	10	1.7764	0.005, S
	VA	2.700	10	1.2517	
Eccentric	FGP	2.800	10	1.1353	0.024, S
	VA	1.900	10	.5676	

Wilcoxon test

Mean number of adjustments, both centric & eccentric, done were significantly high among FGP groupas compared to VA group.

Graph4:



DISCUSSION:-

One of the major factors governing the success or failure of a prosthesis is the occlusal interferences in both centric and eccentric movements. It is very important to check the occlusal contacts as both under occlusion and unwanted occlusion can both lead to functional problems and in turn harm the abutment tooth.

Centric relation is a maxilla-mandibular relationship, independent of tooth contact, in which the condyles articulate in the anterior-superior position against the posterior slopes of the articular eminences; in this position, the mandible is restricted to a purely rotary movement; from this unstrained, physiologic, maxilla-mandibular relationship, the patient can make vertical, lateral or protrusive movements; it is a clinically useful, repeatable reference position. Centric occlusion is the occlusion of opposing teeth when the mandible is in centric relation which may or may not coincide with maximum intercuspation. Eccentric relation is any relationship of the mandible to the maxillae other than centric relation Eccentric occlusion is an occlusion other than maximal intercuspal position.Working side is the side toward which the mandible moves in a lateral excursion. Working-side contacts is the contact of teeth made on the side of the articulation toward which the mandible is moved during working movements. Non-working side is that side of the mandible that moves toward the medial line in a lateral excursion. Non-working contacts are contact of the teeth on the side opposite to the direction of laterotrusion of the mandible. Meyers came up with an occlusal scheme called the Functionally Generated Path which records dynamic occlusion instead of static occlusion. According to him no occlusal adjustments is necessary if the technique is performed properly.[10,11,12]

The present research is based on the comparative evaluation of occlusal contacts and number of occlusal adjustments in FGP technique and virtual articulator on a single provisional prosthesis on lower 1st molar with intact occlusion. In this method the FGP was recorded after the biomechanical preparation of tooth is done on the lower 1st molar using an occlusal table and pattern resin .The mean number of occlusal contacts in FGP at centric after the first four adjustments were 3.9, 5.4, 5, 6.6 respectively. The mean number of occlusal contacts in the prosthesis fabricated using virtual articulator at centric after the first four adjustments were 7, 9.7, 9.2, 10 respectively. The mean number of occlusal contacts in the provisional prosthesis fabricated using virtual articulator were significantly more. The mean number of occlusal corrections made in FGP at centric was 6.4 and the mean value of occlusal corrections in virtual articulator at centric was 2.7.The number of occlusal corrections at centric is more in FGP than in virtual articulator significantly. The mean value of number of occlusal contacts in prosthesis fabricated using FGP technique at eccentric after the first two adjustments were 4.6 and 4.7 respectively where as in the prosthesis fabricated using virtual articulator was 4.4 and 5.3 respectively. The number of occlusal contacts were marginally more in the prosthesis fabricated using virtual articulator than from the prosthesis fabricated using FGP. The mean value of occlusal corrections in FGP at eccentric was 2.7 whereas the mean value of number of occlusal corrections in a prosthesis using a virtual articulator was 1.9. The number of occlusal adjustments in virtual articulator was less in both centric and eccentric than that of FGP proposed by Meyers.[13,14,15,16] (table 1,2,3,4 and graph 1,2,3,4)

FGP was a technique developed in the year 1930. According to Meyers the prosthesis fabricated using FGP needed no occlusal corrections[2] but in the present study conducted this was not true as the occlusal corrections done in the prosthesis fabricated using FGP were significant. The virtual articulator is one such device which reduces the mechanical work and develops a much accurate prosthesis than the conventional FGP technique.[17,18]

According to Pankey and Mann all occlusal interferences were avoided when they used the modified FGP technique but in our study the mean number of occlusal corrections in FGP at centric and eccentric were 6.4 and 2.7 respectively. According to Saafi J et al there was absolutely no kind of patient discomfort with the prosthesis obtained using the FGP technique which was not true in our study as there was more patient discomfort in prosthesis fabricated using FGP than that of the prosthesis fabricated using VA. Programming of the virtual articulator was first described by Kordass and Gartner in the year 1999. On comparing the DentCAM® virtual articulator with a mechanical articulator (Comp. KaVo, DLeutkirch), the same number of contacts were obtained in the lateralization movements with both articulators in 8 patients (mechanical articulator: 90; virtual articulator: 92). In present study, it was found that virtual articulator has a greater number of contacts and

needed less adjustments and had more patient compliance. According to Solaberrieta E et al the most accurate occlusal surface reproduction can be achieved either by using fully adjustable articulator that simulates mandibular movements with high degree of precision or by using virtual articulators with CAD/CAM systems as shown in our study where the accuracy of the prosthesis using virtual articulator is more. Singh K et al stated that the virtual articulator is a precise software tool that deals with the functional aspects of occlusion along with CAD/CAM systems substituting conventional procedures. Pröschel et al. carried out a study of 57 asymptomatic patients in order to determine the occlusal errors appearing in the mechanical articulators. To this effect comparisons were made with the virtual articulator, yielding an error in the second molar of 200 µm in 16% of the patients and of 300 µm in 6% of the subjects – this implying a low risk of error, though the acceptable limits in clinical practice could be exceeded[34]. Song and Baekcarried out a study in 25 patients previously subjected to orthodontic treatment and who were programmed for Le Fort 1 fracture in the maxilla and a sagittal osteotomy in the mandible. The authors compared the precision of the surgical model and of the splints, concluding that the virtual method is more precise than the conventional approach.[15,19,20,21]

LIMITATIONS OF PRESENT STUDY: As the impression is made from irreversible hydrocolloid there is a chance of distortion due to syneresis and imbibition.The volumetric expansion of the dental stone type-3 has not been taken into consideration**.**Direct scanning was not done so there is a scope of error particularly while scanning the casts.PMMA has an inherent nature of volumetric shrinkage which is not been taken into consideration.The articulating paper used was of 10µm which is not as precise as T scan.

CONCLUSION: In the era of modern dentistry new methods such as articulation through a virtual articulator has developed better results in terms of occlusal adjustments both in centric and eccentric contacts. By the present study virtual articulator has been deemed better in terms of both patient compliance as well as operator's ease in delivering of the prosthesis.

CONSENT:-It has been taken individually from all the patients.

ETHICAL APPROVAL:-Ethical approval was taken from institutional ethical research cell committee.

COMPETING INTERESTS:-Authors have declared that no competing interests exist.

REFRENCES:-

1. Davies S and R. M. J. Gray. "What Is Occlusion?" *British Dental Journal* 191, no. 5 (September 2001): 235–45.

2. Meyer, Frederick S. “The Generated Path Technique in Reconstruction Dentistry: Part I: Complete Dentures.” *Journal of Prosthetic Dentistry* 9, no. 3 (May 1, 1959): 354–66.

3. DuVall, Nicholas B., and Paul M. Rogers. “Application of the Functionally Generated Path Technique to Restore Mandibular Molars in Bilateral Group Function Occlusion.” *Journal of Prosthodontics: Official Journal of the American College of Prosthodontists* 22, no. 3 (April 2013): 226–32.

4. “Virtual Articulators and Virtual Mounting Procedures: Where Do We Stand? - PubMed.” Accessed March 31, 2022.

5. “The Virtual Articulator in Dentistry: Concept and Development - PubMed.” Accessed March 31, 2022.

6. Maestre-Ferrín, Laura, Javier Romero-Millán, David Peñarrocha-Oltra, and María Peñarrocha-Diago. “Virtual Articulator for the Analysis of Dental Occlusion: An Update.” *Medicina Oral, Patología Oral y CirugíaBucal* 17, no. 1 (January 2012): e160–63.

7. Li, Linlin, Yuchun Sun, Yong Wang, Weiwei Li, Ning Dai, Sukun Tian, and Haihua Cui. “Accuracy of a Novel Virtual Articulator for Recording Three-Dimensional Dentition.” *The International Journal of Prosthodontics* 33 (July 1, 2020): 441–51.

8. Kumar, Prince, Ashish Kumar, Ashish Khattar, and Roshni Goel. “Significance of Virtual Articulators: An Overview.” *International Journal of Health & Allied Sciences* 1, no. 4 (October 1, 2012): 297–297.

9. Song, Kyu-Gin, and Seung-HakBaek. “Comparison of the Accuracy of the Three-Dimensional Virtual Method and the Conventional Manual Method for Model Surgery and Intermediate Wafer Fabrication.” *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics* 107, no. 1 (January 2009): 13–21.

10. Özdemir, Gökhan, Berkman Albayrak, Emir Yuzbasioglu, and Yesim Us. “Virtual Articulators, Virtual Occlusal Records and Virtual Patients in Dentistry.” *Journal of Experimental and Clinical Medicine* 38 (May 19, 2021): 129–35.

11. Jaffe, Victor N. “The Functionally Generated Path in Full Denture Construction.” *The Journal of Prosthetic Dentistry* 4, no. 2 (March 1954): 214–21.

12. Pankey, Lindsey D., and Arvin W. Mann. “Oral Rehabilitation: Part II. Reconstruction of the Upper Teeth Using a Functionally Generated Path Technique.” *Journal of Prosthetic Dentistry* 10, no. 1 (January 1, 1960): 151–62.

13. Zimmermann, Edward M. “Modifications of Functionally Generated Path Procedures.” *Journal of Prosthetic Dentistry* 16, no. 6 (November 1, 1966): 1119–26.

14. “A Modified Functionally Generated Path Technique for Making Maxillary Posterior Ceramometal Restorations - PubMed.” Accessed March 31, 2022.

15. Weingärtner, Tim, Stefan Hassfeld, and RüdigerDillmann. “Virtual Jaw: A 3D Simulation for Computer Assisted Surgery and Education.” *Studies in Health Technology and Informatics* 50 (February 1, 1998): 329–35.

16. Kordass, Bernd, Christian Gärtner, Andreas Söhnel, Alexander Bisler, Gerrit Voss, Ulrich Bockholt, and Stefan Seipel. “The Virtual Articulator in Dentistry: Concept and Development.” *Dental Clinics of North America* 46, no. 3 (July 2002): 493–506, vi.

17. Bisler, A., U. Bockholt, B. Kordass, M. Suchan, and G. Voss. “The Virtual Articulator.” *International Journal of Computerized Dentistry* 5, no. 2–3 (July 2002): 101–6.

18. Delong, Ralph, Ching-Chang Ko, Gary C. Anderson, James S. Hodges, and W. H. Douglas. “Comparing Maximum Intercuspal Contacts of Virtual Dental Patients and Mounted Dental Casts.” *The Journal of Prosthetic Dentistry* 88, no. 6 (December 2002): 622–30.

19. “Design of a Virtual Articulator for the Simulation and Analysis of Mandibular Movements in Dental CAD/CAM.” Accessed March 31, 2022.

20. Ghanai, S., R. Marmulla, J. Wiechnik, J. Mühling, and B. Kotrikova. “Computer-Assisted Three-Dimensional Surgical Planning: 3D Virtual Articulator: Technical Note.” *International Journal of Oral and Maxillofacial Surgery* 39, no. 1 (January 2010): 75–82.

21. Solaberrieta, Eneko, RikardoMínguez, Lander Barrenetxea, and OlatzEtxaniz. “Direct Transfer of the Position of Digitized Casts to a Virtual Articulator.” *The Journal of Prosthetic Dentistry* 109, no. 6 (June 2013): 411–14.