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"Comparative Evaluation of Masticatory Efficiency and Bite Force in Complete Denture Patients with Two Occlusal Schemes: Monoplane and Lingualized Occlusion" -An In Vivo Study

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ABSTRACT

Purpose: The study aimed to comparatively evaluate the effect of complete denture fabricated with two different occlusal schemes that is Monoplane and Lingualized occlusion on bite force and ability to masticate in completely edentulous patients with resorbed ridges. **Materials and Methods**: Twenty completely edentulous patients with resorbed ridges, ranging in age from 50 to 82 years with willingness to participate in the study were selected from outpatient department. Firstly, 20 patients enrolled in the study protocol were treated with complete dentures fabricated with Monoplane occlusal scheme (group 1) and then the same 20 patients were treated with complete dentures having Lingualized occlusal Scheme (group 2). Main objective outcome variables involved were evaluating and comparing greater positive results for masticatory efficiency and bite force in Complete Dentures fabricated by incorporating Monoplane and lingualized Occlusal scheme. Statistical assessments of two groups were compared and analysed using unpaired or independent 'student' t-test and the level of the significance of the test. **Results**: The occlusal scheme incorporated exhibited significant correlations with masticatory performance in terms of number of particles left on sieve and weight of particles left on sieve (P = .001). The occlusal scheme incorporated exhibited significant correlations with Bite Force (p=.034). **Conclusion:** The study revealed that edentulous patients who received complete dentures with Lingualized occlusion expressed greater masticatory performance and generated increased biteforce with their denture**.**
Keywords: Monoplane occlusion (MO): Lingualized occlusion (LO), Masticatory Efficiency, Bite force

INTRODUCTION

The rehabilitation of completely edentulous individuals with resorbed ridges is conventionally done with the fabrication of Removable Maxillary and Mandibular Complete Dentures. Acceptance of fabricated prosthesis by such individuals is dependent on its ability to aid in chewing and penetrating the food during mastication because, along with bone loss, there is loss of muscle tone and chewing strokes are smaller, which has a significant impact on a patient's quality of life. [1] A detailed examination, precise impressions, a tissue healing

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period, stable and well-adapted denture bases, recording vertical dimension of occlusion, appealing aesthetic, occlusal scheme, occlusion correction, and post denture insertion care for the patient, and patient education all precede the fabrication of successful Complete Dentures that can satisfy the patient. When such tools are used consistently, they produce better results by using easy-to-follow methods. [2]

The removable prosthesis's main objective in resorbed ridges is to restore masticatory function by generating enough bite force to crush the food and aid in mastication by forming bolus which can be then swallowed. Perceived overall health appears to be significantly and favorably impacted by prosthodontic therapy. [3-4] Various mechanical, biological, and physical elements must be acknowledged, understood, and considered to fabricate the complete denture. **Jacobson et al** [5]in 1983, added that the intaglio surface, polished surface, and occlusal surface designs all had an impact on retention, stability, and support.

Regarding the best posterior occlusal forms recommended for Maxillary and Mandibular Complete Dentures in resorbed ridges, there are different schools of thought. S.H.Payne advocated the concept of lingualized occlusion (LO) whereas Sears advocated Non anatomic occlusion. **Sutton et al**. (2007) compared posterior occlusal forms for complete dentures and concluded that patients were more satisfied with Lingualized Occlusion and Balanced Occlusion compared to Zero Degree Occlusion.[6-7] **Matsumaru Y.**(2010) investigated the impact of resorption of mandibular residual ridge on objective masticatory measures in dentures fabricated with lingualized and bilateral balanced occlusal schemes and inferred that for patients with substantial residual resorbed ridge lingualized occlusion is the preferred occlusal scheme. [8] There is currently a dearth of comparative information and no consensus on indicating which kind of occlusal scheme is best for completely edentulous patients with residual resorbed ridges. Therefore, the present study was conducted to evaluate and compare masticatory efficiency and bite force in complete denture patients with two occlusal schemes: monoplane and lingualized occlusion.

MATERIALS AND METHODS
STUDY POPULATION

The study was conducted on twenty edentulous patients with resorbed residual ridges, selected from Outpatient Department of SGT Dental College, aged between 50 -82, who had consented to receive two sets of new complete dentures. Those with any systemic disease/in comorbid condition/on radiotherapy or chemotherapy or with neurologic diseases were excluded from the study. Before the commencement of the study, a protocol was submitted to the research review board of Shree Guru Gobind Singh Tricentenary Dental College, Budhera, Gurugram. The study was started after the ethical clearance was issued by the Ethical Board. The study was reviewed and approved by the institutional review board (Ref no: SGTU/FDS/MDS/24/1/672).
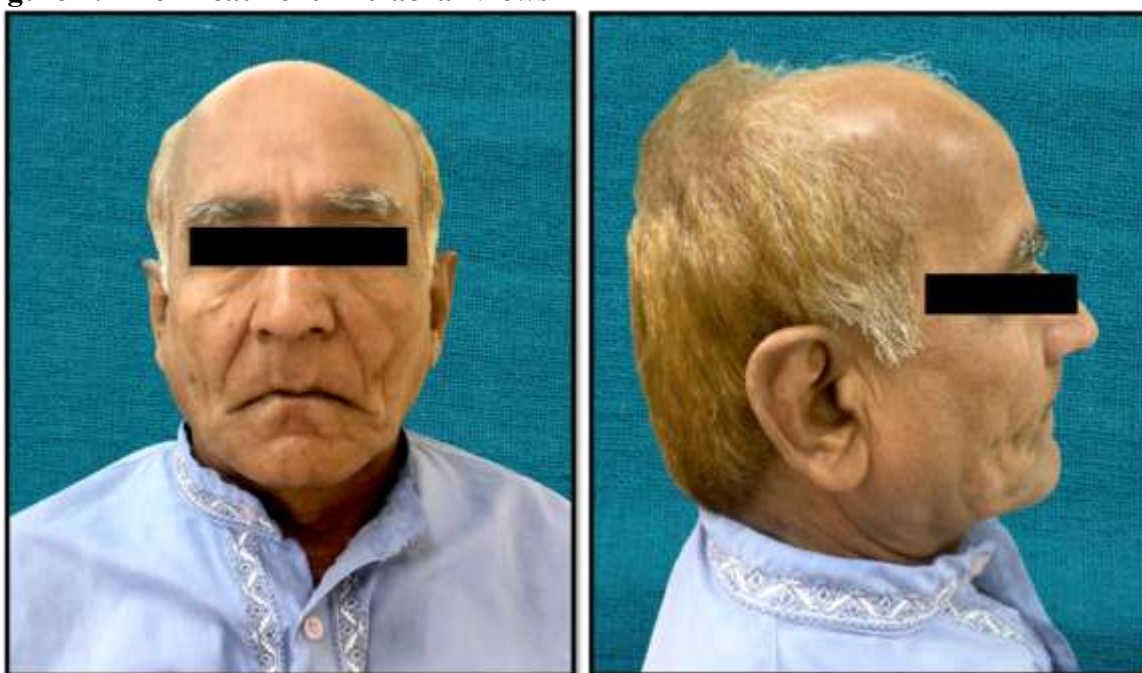
STUDY DESIGN

The prospective study was carried out in the Department of Prosthodontics, Crown & Bridge, and Oral Implantology, SGT Dental College between the year 2021-2022. Twenty patients with resorbed ridges figure 1(a,b&c) were first selected then two sets of complete dentures were fabricated for every subject, one set with Monoplane occlusal scheme and the second set with Lingualized occlusal scheme.

TREATMENT PROTOCOL

A preliminary impression using stock edentulous trays and impression compound Type II Medium Fusing Impression compound was made to obtain Maxillary and Mandibular Diagnostic casts of resorbed ridges, **figure2**(a,b&c) in Type II (Dental Plaster). Custom trays

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were fabricated using self-cure acrylic resin and final impression was made using all green technique for resorbed ridge and the Master cast was obtained using Type 3 (Dental Stone). Both the models were then duplicated in the lab using Agar Hydrocolloid impression material (castogel). A set of base plates and occlusal bite rims were made for jaw relations. Final jaw relations were mounted on semi-adjustable articulators. Occlusal rims were duplicated in the lab. Teeth arrangement was done according to the Monoplane occlusion concept in one set and the Lingualized occlusion concept was followed for teeth arrangement on the other. The monoplane occlusal scheme complete denture was inserted first, and the patient was made to wear the denture for 15 days. Masticatory efficiency and bite force was evaluated after 15 days. Thereafter the patient was advised discontinuation of denture for 01 week. The patient was then asked to wear the complete denture with lingualized occlusal scheme and after wearing it for 15 days the patient was then evaluated for Masticatory efficiency and bite force.

Figure 1: Pre-Treatment Extraoral Views

Fig1a: Frontal View   **Fig 1b: Lateral View**

Figure 2: Intraoral pictures

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Fig 2a: Maxillary arch   **Fig 2b: Mandibular arch**

Fig 2c: U/L Edentulous Arches: Intraoral View

LAB PROTOCOL

The Complete Denture artificial teeth were arranged following two occlusion concepts: Monoplane and Lingualised occlusion.

ARRANGEMENT OF TEETH FOLLOWING MONOPLANE OCCLUSION CONCEPT

After jaw relations, non-Anatomic or cuspless teeth were selected and the anterior teeth were arranged with overjet. After positioning the anterior teeth, shaping of the mandibular occlusal rim was done to form occlusal plane that extends from the tip of the mandibular canines to the middle of the retromolar pads. The occlusal rims fabricated were of the same height and were parallel bilaterally and antero posteriorly. The mandibular cast was surveyed and then the centre of ridge was transferred on the rim. Mandibular wax rim with scribed line served as a guide for maxillary arch teeth arrangement. The teeth arrangement exhibits flat surface when viewed laterally against the horizontal plane. Canines were modified so that they had blunt incisal edges rather than pointed ones. Figure:3(a,b&c)

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Figure 3 a: Frontal view

Figure 3b: Right Lateral View   **Figure 3c: Left Lateral View**

ARRANGEMENT OF TEETH FOLLOWING LINGUALIZED OCCLUSION
In the second set of jaw relations, Semi Anatomic teeth and non-anatomic teeth were selected, and the anterior teeth arrangement was done in a conventional way with Overjet and Overbite. Posterior teeth were arranged in a way that buccal cusps were out of contact, but the palatal cusps were in contact in Centric, Working, and Balancing movements. Compensating Curve was produced by slightly elevating the distal half of the first molar and the second molar. Maxillary Posterior teeth lack buccal cups contact in centric relation and lateral excursion. This was achieved by positioning the Maxillary posterior teeth buccal cusp 1mm superior to the maxillary lingual cusp. Figure4(a,b-c)
Try-in was done with both schemes in the patient's mouth. Acrylization of both Dentures was done using Heat cure acrylic resin.

Figure 4a: Frontal view

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Figure 4b: Right Lateral View   **Figure 4c: Left Lateral View**

MAIN OUTCOME VARIABLES

MASTICATORY EFFICIENCY ASSESSED USING THE SIEVE TEST

1. 12 gms of Peanuts were used as Test Material.
2. The subjects were directed to chew Test Material for 10 and 20 masticatory strokes and were made to sit upright.
3. The collected masticated material was immediately spread on the sieve 1 mm. Figure 5
4. On a Digital Balance, the number of particles left on the sieve was weighed.
5. The test was performed on day 15th post-Denture insertion.
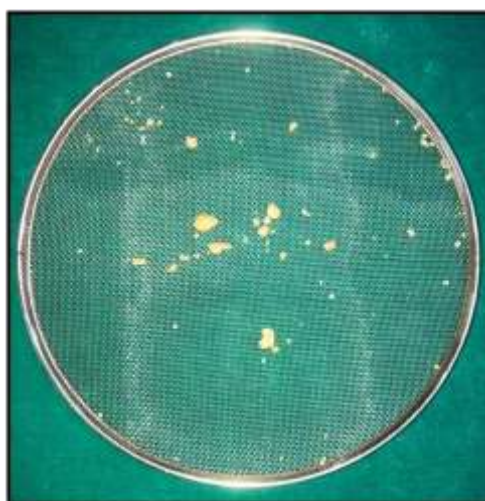
Figure 5: Sieve Test

PATIENT BITE FORCE ASSESSMENT USING FLEXI FORCE ELF SYSTEM

The Flexi Force ® sensors were used to measure static force. The ELF sensors (figure 6) used resistive-based technology. Bite Force software provided a graphical representation of the force as Pounds or Newtons, Grams, and Kilograms. The sensor in real-time records this information as a "movie," to review and analyze later. The Real-time force data was displayed as a "strip chart," "column graph," or "digital readout." The test was performed on day 15.

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Figure 6 : FLEXIFORCE ELF

STATISTICAL ANALYSIS

For the continuous variables, descriptive statistics were computed by computing the mean and standard deviation. Absolute numbers and percentages were used to represent categorical variables. SPSS (statistical package for social sciences) version 25.0 was used for the statistical analysis.

The statistical tests used were independent t-test and the p-value <.05 was considered significant and a confidence interval of 95% was taken.
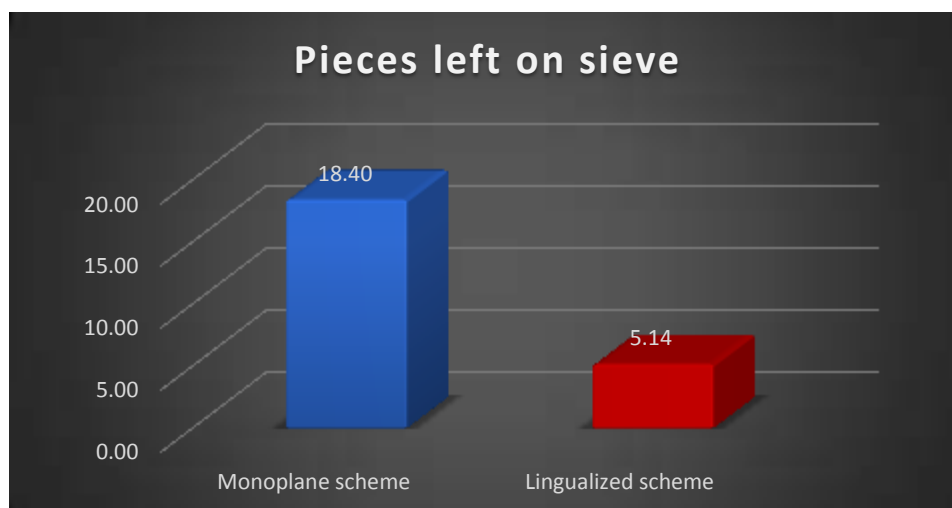
RESULTS

Table 1: Distribution of study population according to number of pieces left on sieve after 20 cycles

	Monoplane scheme		Lingualized scheme			
Cycles 20	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**	**Mean Difference**	**p-value**
Pieces left on sieve	18.40	4.26	5.14	0.85	13.26	0.001*

The mean Pieces left on sieve was significantly more among Monoplane scheme compared to Lingualized scheme.

Graph 1: Comparative evaluation of masticatory efficiency between monoplane and lingualized occlusion according to the number of pieces left on the sieve after 20 cycles (n=20)

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COMPARATIVE EVALUATION OF MASTICATORY EFFICIENCY BETWEEN MONOPLANE AND LINGUALIZED OCCLUSION ACCORDING TO THE WEIGHT OF PIECES ON THE SIEVE AFTER 20 CYCLES

Table 2: Comparative evaluation of masticatory efficiency between monoplane and lingualized occlusion according to the weight of pieces left on the sieve after 20 cycles (n=20)						
	Monoplane Occlusal Scheme		**Lingualized Occlusal Scheme**			
Cycles 20	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**	**Mean Difference**	**P-Value**
Weight of pieces left on the sieve	16.20	4.89	6.00	1.02	-10.20	0.001*

Table 2 depicts the comparison of Mean± SD values of the weight of pieces left on the sieve after 10 cycles in the Monoplane and Lingualized Occlusal scheme.

GRAPH 2: Comparative evaluation of masticatory efficiency between monoplane and lingualized occlusal scheme according to the weight of pieces left on the sieve after 20 cycles (n=20)
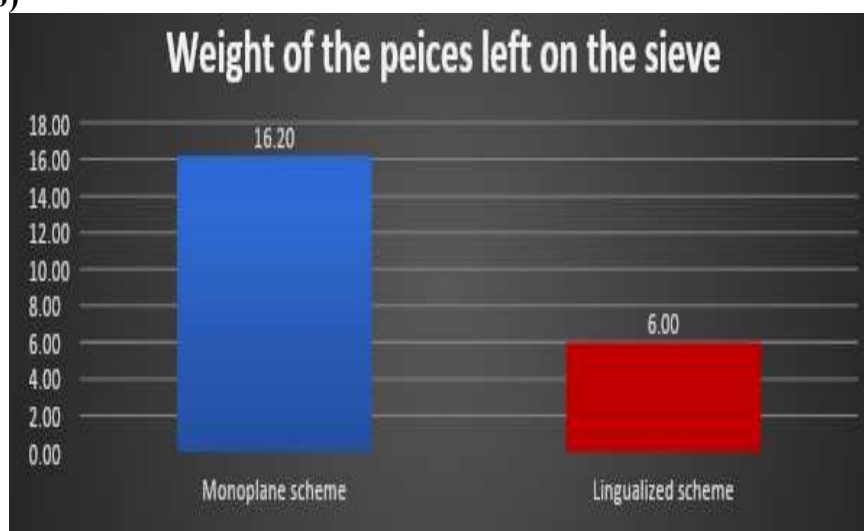

COMPARATIVE EVALUATION OF BITE FORCE (IN NEWTON) IN MONOPLANE AND LINGUALIZED OCCLUSAL SCHEME

TABLE 3: Comparative evaluation of bite force (in newton) in monoplane and lingualized occlusal scheme (n=20)				
	Mean	**Std. Deviation**	**Mean Difference**	**P-Value**
Monoplane scheme	218.45	61.98	-52.33	0.034*
Lingualized scheme	270.78	57.79		

Table 3 depicts the comparison of Mean± SD values of Bite force in newton in Monoplane and Lingualized Occlusion.

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Graph 3: Comparative evaluation of bite force (in newton) in monoplane and lingualized occlusal scheme
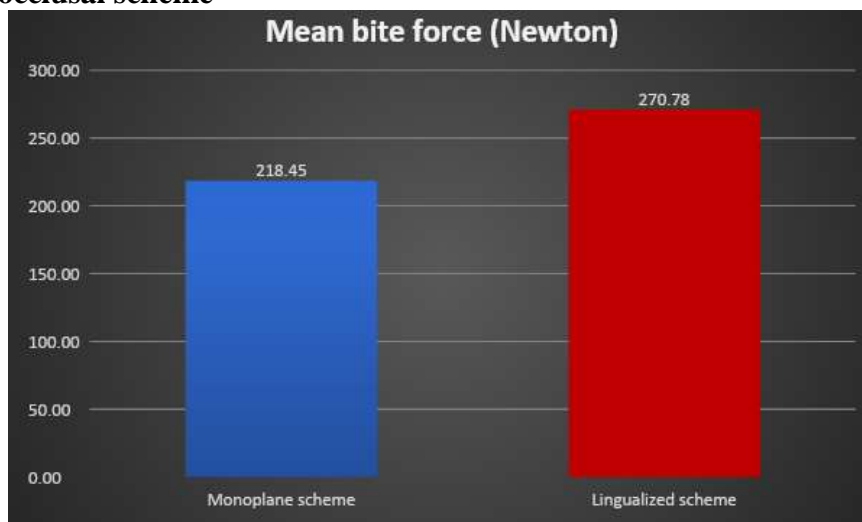
Graph 1 shows that the mean value of the number of pieces left on the sieve was significantly more among the complete denture fabricated with Monoplane occlusion as compared to the Lingualized occlusion. Table 1 shows the mean value of the number of pieces left on the sieve in the Monoplane occlusion was 18.40 with standard deviation ±4.26 whereas the mean value of the number of pieces left on the sieve in the Lingualized occlusion was 5.14 with standard deviation ±0.85. The mean difference between the Monoplane occlusion and the Lingualized occlusion was 13.26 and the p-value determined by independent t-test was 0.001.

Graph2 shows that the mean value of the weight of pieces left on the sieve was significantly more among the complete denture fabricated with Monoplane occlusion as compared to the Lingualized occlusion. Table 2 shows the mean value of the weight of pieces left on the sieve in the Monoplane occlusion was 16.20 with standard deviation ±4.89 whereas the mean value of the weight of pieces left on the sieve in the Lingualized occlusion was 6.00 with standard deviation ±1.02. The mean difference between the Monoplane occlusion and the Lingualized occlusion was -10.20 and the p-value determined by independent t-test was 0.001.

Graph 3 shows that the mean value of bite force was significantly higher among the Lingualized scheme as compared to the Monoplane scheme using Flexiforce ELF. The mean value of bite force obtained in the Monoplane occlusion was 218.45 with standard deviation ±61.98 while the mean value of bite force obtained in the Lingualized occlusion was 270.78 with standard deviation ±57.79. The mean difference between the Monoplane occlusion and the Lingualized occlusion was -52.33 and the p-value obtained through independent t-test was 0.034.

DISCUSSION

According to the findings, edentulous patients with resorbed ridges who received complete dentures with lingualized posterior occlusal schemes performed better. Edentulism has long been considered a key sign of a society's dental health and a determinant of the illness of any person. Patients with edentulous mouth seek denture therapy primarily to restore function. Occlusion is one of the key factors thought to be crucial for Complete Denture's success. Any force applied to a single denture tooth is instantly forwarded to the remainder of the denture since the Denture functions as a single unit. Several occlusal approaches for Complete Dentures have arisen to get around this restriction. The lateral stresses acting on Complete Denture and residual ridge can be affected by changing the occlusal pattern and posterior tooth shape.

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Gibbs et al (1981) [9] proposed that people wearing Complete Dentures experience an average closing force or chewing force of 11.7 pounds during mastication, which is much less than the lowest closure force experienced by subjects with natural teeth. According to research on both artificial and natural teeth, it was inferred that complete denture users are able to generate only 10% to 15% of the force in comparison to individual with healthy natural teeth. Therefore, a Complete Denture wearer can hardly generate enough force to do the mastication. [7-8] Despite the fact that Complete Dentures had been used in Prosthodontics, for millennia, no single occlusal theory has a strong foundation in evidence for the management of resorbed residual alveolar ridge.

Ohara A et al (2003) [10] evaluated the masticatory performance using the sieve test for 10 and 20 chewing strokes. They used different mesh sizes for the sieve and when the number of chewing strokes exceeded 25, the rate at which the number of particles increased started to decline. As a result, they selected 10 and 20 chewing strokes to simplify things even further. They observed a clear linear association between 10 and 25 chewing strokes on the 1.4mm and 1.18-mm mesh sieves and concluded that the quantity of masticated particles on a given sieve should rise as the number of chewing strokes increases. Their findings demonstrated that calculating masticatory performance from two mastication endeavor (ten and twenty strokes) using mesh sieves of size 1.4-mm and 1.18-mm was not significantly different from calculating masticatory performance from seven mastication tasks. This outcome demonstrated that reducing mastication endeavours had no impact on the measured masticatory performance value.

The Masticatory efficiency was evaluated in our study between the Monoplane scheme and the Lingualized occlusion [TABLE-1 and 2] at 20 chewing strokes through the sieve test (size of mesh=1.00 mm). Roasted peanuts were used because chewing made it simple to comminute the particles. The absorbed water could be quickly removed, and sieving would make it simple to separate the aggregate of comminuted particles. The consistency of other natural test foods may vary due to food preparation, seasonal and regional factors, and environmental factors. [8]It was observed that the mean difference between the Monoplane scheme and the Lingualized scheme for the number of pieces left on the sieve was 13.26 and the p-value obtained was 0.001 [TABLE-1 and GRAPH-1]. The mean value of the number of pieces left on the sieve was significantly more among the Monoplane scheme as compared to the Lingualized scheme in 20 cycles. The mean difference between the Monoplane scheme and the Lingualized scheme for the weight of the pieces left on the sieve was -10.20 and the p-value obtained was 0.001 [TABLE-2 and GRAPH-2]. The mean value of the weight of the pieces left on the sieve was significantly more among the Monoplane scheme compared to the Lingualized scheme in 20 cycles. Similar observations were made by **Gibbs et al (1981)** [9] reported that Lingualised occlusion increased mandibular complete denture stability and occlusal force are distributed to the non-working side's supporting structure thereby suggesting the superiority of the Lingualized occlusion. Similarly, **Clough HE al (1983)** [13]**, Ahmed AR et al (2013)** [14]**, and Deniz AZ (2013)** [15] preferred Lingualized occlusion over Monoplane occlusion because of better food bolus penetration and improved bite force.

The Static Bite force was evaluated between the Monoplane scheme and the Lingualized scheme using the ELF Flexi Force ® sensors. It was found that the mean value of the static bite force in the Monoplane scheme was 218.45 N with a standard deviation of ± 61.98. And, in the Lingualized scheme, the mean value of the static bite force was 270.78 N with a standard deviation of ± 57.79. The mean difference between the Monoplane scheme and the Lingualized scheme was -52.33 and the p-value obtained was 0.034 (Table 3 and Graph 3). **Shala k et al (2018)** [16] reported the values of bite force in edentate individuals as 290 N in both females and males and hypothesized that maximum bite force (mBF) was a key differentiating factor in the degree of responses to new Complete Dentures in terms of

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functionality. Black was the first to use masticatory force measurements as well as to investigate in vitro feeding with an instrument "phagodynamometer". The obtained values for denture wearers ranged between 90N and 360N. Our values are within the range.

CONCLUSION

Based on the comparative evaluation of both Monoplane occlusion and Lingualized occlusion, the following conclusions were drawn that completely edentulous patients with resorbed ridges wearing complete denture fabricated by incorporating Lingualised occlusal scheme demonstrated significantly increased masticatory efficiency after 20 chewing strokes and markedly higher bite force as compared to the Monoplane scheme. The Lingualised occlusal scheme can be considered as better alternative for managing patients with resorbed ridges as it allows formation of soft bolus due to improved penetrability enabling easy swallowing of food while maintaining other functions of stomatognathic system.

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