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(Research Article)
Comparison of canine guidance and bilateral balanced occlusion concepts of complete dentures on patients' masticatory efficiency: An *in vivo* study

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Abstract
The aim of this study was to compare the masticatory efficiency with bilateral balanced occlusion and canine guidance occlusion in complete dentures. The study was conducted on 30 patients. The patients were randomly divided into two groups of 15 patients each, one with bilateral balanced occlusion dentures and the other with canine guidance. After 3 months, bilateral balanced occlusion scheme was converted to canine guidance and vice-versa for further 3 months. The influence of the two occlusal concepts on masticatory efficiency was determined using photocolorimeteric test. The data so collected was compared and analyzed statistically. The masticatory efficiency was greater with bilateral balanced occlusion complete dentures but the difference was statistically nonsignificant as compared to canine guided complete dentures. The results of the study suggested that canine guidance occlusion concept can also be used in complete dentures as it is simple, easy and less time consuming as compared to bilateral balanced occlusion.

Keywords: Complete dentures, masticatory efficiency, bilateral balanced occlusion, canine guidance occlusion

Introduction
Complete denture occlusion is not only the arrangement of maxillary and mandibular teeth, but an important part of the stomatognathic system. It must be developed to perform the various functions efficiently and with least amount of trauma to the supporting tissues. Occlusion is closely related to the physical aspects of load distribution, denture retention & stability, and it is an important aspect of the technical process in complete dentures fabrication [1]. The pattern of occlusal contacts between opposing teeth during centric relation and functional movements of mandible is determined by occlusal scheme. The word "occlusal scheme" can be defined as 'the form and the arrangement of occlusal contacts in natural and artificial dentition [2].' An optimal occlusal scheme is the essential and critical factor in the design of complete dentures prosthesis as it has effect on the muscle activity during mastication process. Over the past 100 years, various concepts of occlusion & articulation as bilateral balanced, neutrocentric, lingualized, monoplane and canine guidance occlusion etc have been advocated for the fabrication of complete dentures. A balanced articulation, the bilateral simultaneous contacting of the maxillary and mandibular teeth in the posterior & anterior occlusal areas in centric and eccentric positions, has been the most widely used occlusal concept for edentulous patients and has formed the basis of all later occlusion concepts [3]. It is considered to provide better masticatory function since this type of occlusion brings more grinding surface in contacts at each centric and eccentric movement. It helps to distribute the occlusal load evenly across the arch and therefore helps to improve the stabilty of dentures during centric, eccentric or para functional movements. Apart from these traditional concepts, anterior canine guidance was also proposed by some authors for the fabrication of complete dentures. Beck (1972) discussed the Aull' concept concept of non-balanced occlusion in which 33 degree cusp form posteriors with full gold occlusal surfaces were used and the anterior teeth were arranged according to phonetics, and in centric occlusion, contact forces were directed toward the ridge while during eccentric lateral positions, cuspid guidance discluded the posterior teeth [4].

Anterior canine guidance occlusal scheme is much easier to achieve and disengages the posterior teeth during all eccentric mandibular movements by vertically and horizontally overlapping the canines. Canine guidance occlusion concept is considered to reduce muscle activity during protrusive and lateral excursive mandibular movements. But, proponents of bilateral balanced occlusion argue that this occlusion scheme stabilized the complete dentures and centralized the forces on residual ridge to protect the alveolar ridge from resorption [5]. The review of literature revealed that there was no conclusive evidence to support which occlusal scheme could be successfully applied for rehabilitation of edentulous patients. Therefore, a study had been planned to compare the masticatory efficiency with bilateral balanced occlusion and canine guidance occlusion in complete dentures.

Materials and Methods
The present study was conducted on 30 completely edentulous subjects, with age ranging from 45 yrs to 70 yrs, selected from the patients who reported in the out-patient department of Prosthodontics at Govt. Dental College & Hospital, Patiala for the fabrication of complete dentures. All the patients were provided with two complete dentures, and their masticatory efficiency was compared between both occlusal schemes. Patients were randomised into one of the two treatment groups: complete dentures with bilateral balanced occlusion or canine guidance occlusion. The occlusal concept was changed after insertion of complete dentures for 3 months. The masticatory efficiency was assessed objectively with photo-colorimetric test using beet root as test food. A written voluntary informed consent was obtained after informing each participant about the study procedure. The study was approved by the ethical committee of the institution. The patients were selected on the basis of the following inclusion and exclusion criteria.

Inclusion criteria
▪ Good general and oral health with firm resilient alveolar mucosa of moderate thickness covering the entire denture bearing area.
▪ Well healed alveolar ridges in class 1 relationship

Exlusion criteria
▪ Patients with TMJ disorders, intra or extra-oral lesions.
▪ Flabby residual alveolar ridges.
▪ Xerostomia, oral carcinoma, history of irradiation, Ulceration, hyperplasia, any bony undercut or bony exostosis, tori, sharp spiny prominences or any pathology.
▪ Any medication that could affect muscular activity were not included in the study.

Initially, all complete dentures were fabricated with bilateral balnced occlusion. Thereafter, the occlusal scheme was changed into canine guidance by addition of light cured composite resin on mandibular canines.
Maxillary and mandibular preliminary impressions were made using impression compound in suitable sized stock trays. The impressions were immediately poured in dental plaster to make the primary casts. Custom trays were fabricated over the preliminary maxillary and mandibular casts using autopolymerising acrylic resin material. The trays were checked in patient's mouth for stability and adjusted so that the tray borders were 2mm short of the limiting structures. Border moulding was performed using low fusing impression

compound and final impression was made using zinc-oxide eugenol impression paste. The impressions were poured in dental stone to prepare the master casts. On the master casts, record bases and occlusal rims were made using autopolymerising acrylic resin and modelling wax respectively. The maxillary and mandibular occlusal rims were adjusted according to the patient's esthetics, occlusal plane, phonetics and vertical dimension. The maxillary cast was mounted on the upper member of the arcon semi-adjustable articlulator (Hanau wide-vue articulator) using the facebow record. An interocclusal centric relation record was used to mount the mandibular cast to the lower member of the articulator. The horizontal condylar inclinations of the articulator were set using the patient's protrusive interocclusal records.

The anatomic acrylic resin teeth, the anterior according to esthetics and functional guidelines and posterior teeth on the crest of the ridge, were arranged in balanced occlusion using the anatomic landmarks as a guide. The polished surfaces of trial dentures were made by approximate shaping of the wax. The trial dentures were verified in the patient's mouth for acceptable esthetics, phonetics, occlusion and centric relation. The waxed trial dentures were invested and processed using the conventional compression molding technique for construction of heat cured acrylic resin complete dentures. After finishing, the dentures were re-mounted on the articulator and any occlusal discripencies produced in complete dentures were corrected by selective grinding and then finally polished.

Conversion of bilateral balanced occlusion to canine guidance occlusion: The change from bilateral balanced occlusion to canine guidance occlusion was performed clinically on the day of denture insertion for 15 patients (CGO-BBO) and, after 3 month of denture insertion for other 15 patients(BBO-CGO).The change from the bilateral balanced occlusion to canine guidance was performed clinically by addition of light cured composite resin (3M ESPE Z250 XT) on the incisal surface of mandibular canines.

Fig 1: Application of light cured composite resin on incisal edge of mandibular canine

The correct color of composite resin that matched the artificial denture teeth was chosen. Mechanical undercut holes were prepared in mandibular canine with inverted cone carbide bur. A thin layer of adhesive (3M ESPE single bond adhesive) was applied into the mechanical undercut holes & incisal surface using the micro appicator tips and, cured for 20 seconds using light curing unit. The composite resin was

applied into the microundercut holes and was light cured for 40 seconds. After complete polymerization, the occlusal adjustments were done in such a way that it could provide an interarch disclusion space of 2mm in the molar regions during eccentric movements. Then, the surfaces of teeth were finished and polished with soflex disks using composite polishing paste. To change the canine guided occlusion to bilateral balanced occlusion, the composite resin was removed & the teeth surfaces were polished and bilateral balanced occlusion was re-established.
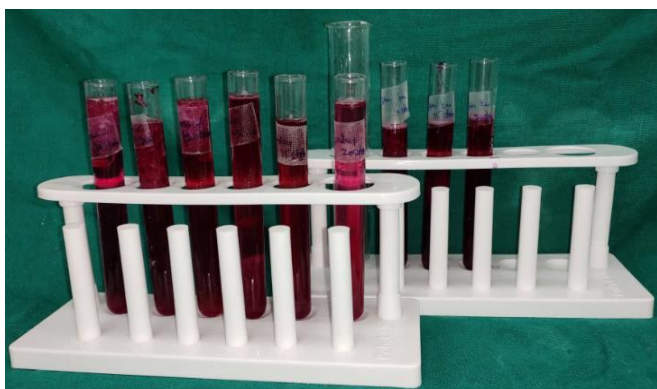

Fig 2, 3: Patient in left eccentric position with Bilateral balanced occlusion and canine guidance occlusion complete dentures respectively

Assessment of masticatory efficiency

The masticatory efficiency of the complete dentures with both the occlusal schemes was assessed objectively by phtocolorimetric method. Raw beetroot was used as a test food for measuring masticatory efficiency [6]. The patient was instructed to chew a piece of raw beetroot weighing 3 grams for 10, 15 and 20 strokes respectively. After chewing the test food, all the saliva produced and collected during the chewing process was expectorated in a graduated cylinder. The samples were transferred into test tubes and 10 ml distilled water was added to each test tube. Then these samples were vortexed using cyclometer at 3000 rpm for 2 minutes. The vortexed solutions were filtered with whitman filter paper. Then, the optical density of these filtrates were recorded in photocolorimeter at 530 nm. The readings were taken for 10, 15 and 20 strokes for each patient for both occlusal scheme. The average reading of these strokes was taken as a mean reading. Average masticatory efficiency was calculated for each patient.

Average masticatory efficiency percentage of patient = Mean masticatory efficiency value / Standardized maximum value (Emax)

For standardized maximum extinct (Emax) or control, a piece of raw beetroot weighing 3 grams was ground in grinder for 90 seconds. All chewed samples were compared to this control value. To standardize the conditions, the control value for test food was determined seperately for each patient.

Fig 4: Collected saliva samples with chewed raw beet root for evaluation of masticatory efficiency

Fig 5: Photocolorimetric reading with collected saliva samples with raw beetroot

The data so determined was analyzed using the software SPSS version 10. Mean and standard deviations were calculated for masticatory efficiency. Student-t test was applied to compare the masticatory efficiency in both the study groups.

The level of significance was taken at $P<0.05$.

Results

More of patients showed improvement in masticatory efficiency with bilateral balanced occlusion complete denture when compared with canine guidance occlusion complete dentures but the difference was statistically non-significance. With balanced occlusion complete dentures, mean percentage of masticatory efficiency was 59.74% and range of masticatory efficiency was 43.48% to 76.23%. whereas, canine guidance occlusion complete dentures showed mean percentage of masticatory efficiency of 54.66% and the range of masticatory efficiency was 36.38% to 75.19%. The student t-test was applied for comparing the masticatory efficiency of bilateral balanced occlusion and canine guidance complete dentures. The value of t = 1.968 and p-value 0.054 ($P>0.05$) exhibited that statistically non-significant difference was found in patients' masticatory efficiency with bilateral balanced occlusion and canine guidance occlusion complete dentures.

Table 1: Comparison of the Patients' Masticatory Efficiency with Bilateral Balanced Occlusion Complete Dentures and Canine Guidance Occlusion Dentures

Masticatory Efficiency	Bilateral Balanced occlusion Complete Dentures	Canine guidance Occlusion Complete Dentures
Minimum	43.48%	36.38%
Maximum	76.23%	75.19%
Mean	59.74%	54.66%
Standard deviation	9.75303	10.26578
t-value	1.968	
p-value	0.054	
Significance	NS	

NS = nonsignificance
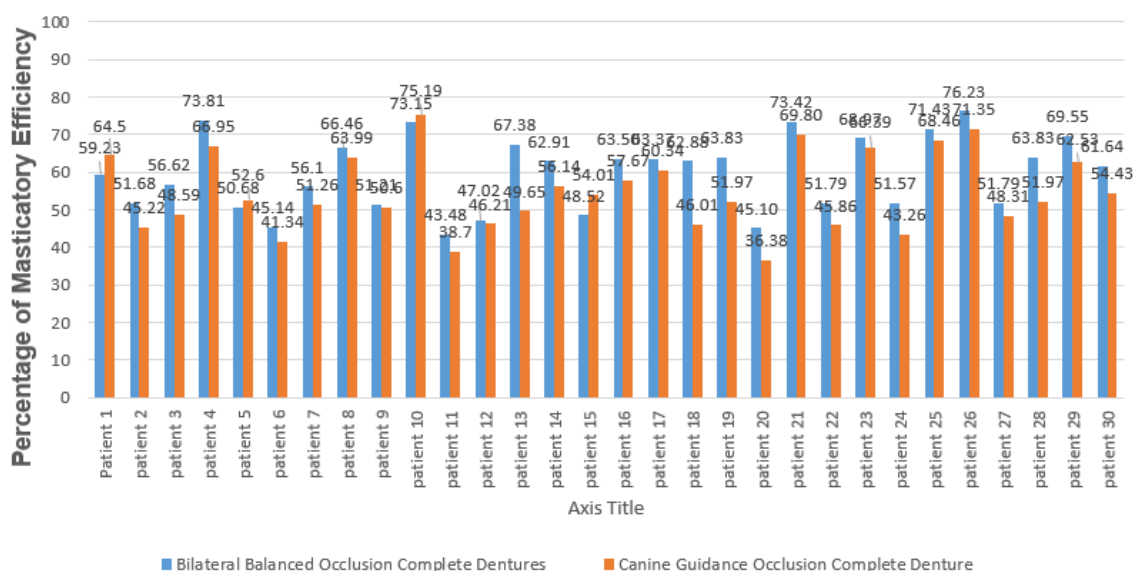
Fig 6: Bar Diagram Showing Percentage of Patients' Masticatory Efficiency with Bilateral Balanced Occlusion & Canine Guidance Occlusion Complete Dentures

Discussion

Optimal outcome of rehabilitation of edentulous patients to restore lost oral structures, function, esthetics and speech with complete dentures depends on successful intergration of the prostheses with patients' oral functions and psychological acceptance of their dentures. Bilateral balanced occlusion, one of the earliest occlusion concept advocated for construction of complete dentures, involves the continuing contacts of as many maxillary and mandibular artificial teeth as possible at centric relation and all eccentric mandibular movements. Canine guidance occlusion, one of the various occlusion schemes suggested for complete dentures, disengages the posterior teeth during excursive mandibular movements by vertically and horizontally overlapping the canines [5]. So both the occlusion schemes have simultaneous occlusal contacts in centric occlusion, but these occlusal contacts differ between two occlusion schemes during eccentric movements [7]. Bilateral balanced occlusion has since long been considered as a fundamental for treatment success but there is no sufficient scientific evidence to support bilateral balanced occlusion as the ideal occlusal concept in complete dentures. The present study had been conducted on 30 edentulous subjects to compare their masticatory efficiency with both bilateral balanced occlusion and canine guidance occlusion complete dentures.15 patients were provided firstly with bilateral balanced occlusion complete dentures while other 15 patients with canine guided occlusion complete dentures. The occlusal concept was changed after wearing of complete dentures by the patients for 3 months. This randomised cross-

over design had the advantage of eliminating the inter-subject response variation to the same treatment [8].
The masticatory efficiency i.e. the capacity to reduce food during mastication, was evaluated using photocolorimetric technique which is considered to be a fast, effective and reproducible method. The most commonly used sieve method was not employed as it is very complex and not able to completely assess the masticatory efficiency because some of the particles might be swallowed and the others dissolved by saliva [9]. Also, raw beetroot was preferred as the test food because it contained naturally occuring dye 'betanin' which was released on chewing and measured photocolorimetrically [6]. The data so obtained was compared and analyzed statistically.
The objective analysis of masticatory efficiency of patients selected in our study exhibited better masticatory performance with bilateral balanced occlusion dentures but the difference was statistically insignificant with p-value = 0.054 (Table 1) .The minimum and maximum percentage of masticatory efficiency with bilateral balanced occlusion complete dentures was 43.48% and 76.23% respectively whereas with canine guided occlusion dentures, the values were 36.38% and 75.19% respectively. The mean average percentage value of masticatory efficiency for bilateral balanced occlusion dentures was 59.75% and for canine guided occlusion dentures, it was 54.66%. The observations of statistically no difference between patients' overall satisfaction of complete dentures with both occlusion schemes were in agreement with the studies conducted by Neto, Junior & Carreiro (2010),

Abbas, Elgindy & AbdElmonem (2016) and Afjal, Mazeed & Mirza (2017) [7, 8, 10]. Neto, Junior & Carreiro (2010) also found no significant difference between both the occlusions regarding the objective assessment of masticatory efficiency. They observed the mean data regarding the objective assessment of masticatory effiiency was 0.186 abs & 0.167 abs for bilateral balanced occlusion dentures and canine guided dentures respectively. Abs is the unit to assess the absorbance of artificial dye used in their objective method. Their data showed better mastication performance for bilateral balanced occlusion but the difference was statistically insignificant with p-value = 0.095 [7]. On the other hand, the findings of Afjal, Mazeed & Mirza (2017) showed better masticatory function for canine guided occlusion dentures than bilateral balanced occlusion types but statistically nonsignificant difference. They evaluated the masticatory performance twice by assessing the masticatory efficiency, number of average chewing strokes & time to reach swallowing threshold. First test was performed when patients chewed for 15 seconds while another one, when chewed till swallowing threshold. The percentage of masticatory efficiency was 39.02% & 41.41% in test-I and 73.95% & 77.37% in test-II for bilateral balanced occlusion dentures and canine guided dentures respectively. The findings for number of average chewing strokes were 19.8 & 19.2 in test-I and 57.65 & 52.80 in test-II for bilateral balanced dentures and canine guided dentures respectively. The time to reach swallowing threshold for bilateral balanced occlusion & canine guided dentures was 53.18 sec & 51.37sec respectively. All their findings in test-I and test-II showed better masticatory performance for canine guidance occlusal dentures but the difference was statistically insignificance [10]. Abbas, Elgindy & AbdElmonem (2016) observed the statistically significant increase of the dye concentration for patients who were provided first with bilateral balanced occlusion complete dentures at first followup period, when compared with patients who were provided first with canine guided occlusion. But this difference was statistically non-significant at second followup period regardless of the occlusion schemes used in their study. There was increase in masticatory efficiency during followup periods with more improvement at the end of the study regardless of the type of occlusal scheme used [8]. The better masticatory efficiency of bilateral balanced occlusion (BBO) complete dentures in present study might be due to more grinding surfaces in contact at centric relation and all eccentric mandibular movements.

Proponents of bilateral balanced occlusion believe that the bilateral balancing contacts at centric and all eccentric positions are important for denture retention and stability [5]. Rehmann *et al*. suggested that bilateral balanced occlusion helped the patients' adaptation to new complete dentures. They supposed that bilateral balanced occlusion minimized rocking movements during protrusion and produced fewer neuronal stimuli that helped the patients adaptation to their new oral conditions [11].

Peroz *et al*. advocated that canine guidance occlusal concept could also be used with success in complete dentures as bilateral balanced occlusion was not the only occlusal principle. They suggested that initially there were some difficulties in adaptation with canine guided dentures i.e. denture ulcers etc, but the patients adapted quickly to the canine guided occlusion and expressed a better sense of chewing ability; better retention of mandibular denture than that seen with bilateral balanced dentures [5].

The results of the present study revealed that a complete denture with canine guided occlusion provides comparable masticatory efficiency when compared to bilateral balanced occlusion dentures.

Certain limitations in the present study might be possiblity of human errors during the conversion of occlusal scheme to canine guidance type with exact 2mm disclusion in molar regions. Also, the subjects with only well formed class-I edentulous alveolar ridges were selected for the study. So the comparable effects of canine guidance occlusion on compromised or resorbed ridges has not been evaulated in the study. Also, no electromyographic activity of muscles of mastication was assessed to evaluate masticatory function. Within the limitations of the present study, it can be concluded that the type of the occlusal scheme does not seem to significantly influence the edentulous patients' masticatory efficiency, particularly in healthy patients with well formed residual alveolar ridges. Though the masticatory efficiency is better with bilateral balanced occlusion dentures but the difference with canine guided occlusion dentures was statistically insignificant. The results of the study suggest that canine guidance occlusion (CGO) concept can be used as an alternative to bilateral balanced occlusion (BBO) as it is simple, easy and less time consuming as compared to bilateral balanced occlusion which is more expensive, technique sensitive and requires more intra-oral adjustments and followups.

Conclusions
However, the masticatory efficiency was greater with bilateral balanced occlusion complete dentures than with canine guided dentures but the difference was statistically insignificant. The results of this study concluded that the type of occlusal scheme did not seem to significantly influence the edentulous patients' masticatory efficiency, particularly in healthy patients with well formed residual alveolar ridges. Therefore, canine guided occlusion concept can be suggested to be used as an alternative to bilateral balanced occlusion in complete dentures as it is simple, easy and less time consuming as compared to bilateral balanced occlusion which is more expensive, technique sensitive and require more intraoral adjustments and followups.

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