



Computer Aided Evaluation of Bite Force in Complete Dentures – An in Vivo Study.

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KEYWORDS

Complete denture, Occlusion, Occlusense, Bite force, Selective Grinding, Digital occlusal analysis.

ABSTRACT:

Introduction: Achieving balanced occlusion in complete denture therapy is critical for comfort, function, and patient satisfaction. Conventional clinical remount procedures are effective but time-consuming and often impractical for elderly patients. This study evaluated the effectiveness of selective grinding guided by digital occlusal analysis using the digital system in improving bite force distribution in complete denture wearers.

Objectives: To evaluate and compare occlusal force percentage in complete dentures.

Methods: A clinical observational study was conducted on 10 completely edentulous patients aged over 40 years, rehabilitated with conventional complete dentures. Following laboratory remounting, occlusal force distribution was recorded using the OccluSense system. High-pressure contact points were identified digitally and clinically and adjusted through selective grinding. Bite force distribution was recorded before and after the adjustment. Statistical analysis included the Statistical analysis used: paired t-test, Mann-Whitney U test, and Kruskal-Wallis test.

Results: The mean bite force on the left side increased from 46.10 ± 2.96 to 48.30 ± 1.95 , while on the right side it decreased from 53.90 ± 2.96 to 51.70 ± 1.95 . The changes were statistically significant ($p < 0.005$), indicating effective redistribution of occlusal forces. No significant differences were observed across gender or age groups.

Conclusions: Selective grinding based on digital occlusion analysis with OccluSense significantly improved occlusal force distribution in complete denture wearers. This approach provides a practical, efficient, and patient-friendly alternative to conventional clinical remounting. However, larger sample sizes and long-term follow-up are recommended to validate these findings.

1. Introduction

Verifying complete denture occlusion intraorally is challenging because of the resilience of supporting tissues and temporomandibular joints, and also due to deflective tooth contacts. Remounting the denture on an articulator and equilibrating it is an accepted method to correct occlusal discrepancies.^[1] However, clinical determination of the necessity for performing remounting procedures is often questionable. The possibility of measuring the amount and distribution of

occlusal loads with minimal interference would be a useful aid in deciding whether remounting is necessary.^[2]

Edentulous patients seek denture treatment to restore function and aesthetics in the most comfortable fashion. One of the most important factor to achieve comfort in CD is correct occlusion, which should provide not only stability to dentures but also sufficient force to chew the food with uniform force distribution throughout the denture foundation.^[3] Presence of deflective occlusal contacts, poor occlusal force summation and unseen



collection of unbalanced forces may result in torque and dislodgement of complete dentures affecting stability, comfort and patient acceptance.^[4]

The extraoral method, or adjusting the occlusion of complete dentures on an articulator, is often referred to as the remount procedure. The clinical remount procedure is to remount the dentures on an articulator with interocclusal records made in the patient's mouth.^[5] Establishing the occlusion and articulation of dentures outside the patient's mouth overcomes the flaws of the intraoral method. Although this procedure is considered complex and time consuming^[6], various study research has established that a clinical remount can efficiently remove occlusal interference, enhance comfort and masticatory performance and reduce the incidence of soreness and tissue irritation.^[7]

However, most research about clinical remounting has focused on newly fabricated dentures. If clinical remounting is effective as a method of occlusal adjustment in new dentures, it should also provide some benefits for existing dentures.^[8] Although expert opinions suggested that periodical clinical remounts should be implemented in the maintenance phase of complete denture treatment, there is an absence of sufficient research and treatment guidelines or any form of review.^[9,10]

On this basis, a computerized occlusal diagnosis system (T-Scan system, Tekscan Inc., Boston, Mass.) was used to ascertain the need for occlusal adjustment in complete dentures. An electronic sensor foil enables the dentist to determine the intensity and distribution of occlusal loads.

Lately, the development of digital technology has revolutionized the dentistry field, allowing us to evaluate with higher precision the occlusal contacts, both in static and dynamic occlusion. OccluSense (Dr. Jean Bausch, GmbH & Co KG, Koln, Germany) is a new occlusal analysis system for recording dental relationships.^[11,12] It consists of a sensor covered in articulating paper which is inserted into the handheld, which records and transmits the data to the OccluSense-iPad-App (Apple Inc., Cupertino, CA, USA). Unlike conventional methods, OccluSense also records the precise moment of the dental contact besides the distribution and intensity of the occlusal force.^[13,14]

However, many research studies, have measured the bite force in dentulous, partially edentulous and completely edentulous patients with different types of prosthesis, but the void in the literature points out to the effect of the type of prosthesis on distribution of bite force. Bilateral balanced occlusion has been advocated for complete dentures. Although bilateral balanced occlusion can be achieved in the articulator, there is no study which shows that bilateral balanced occlusion is achieved clinically and observed through digital occlusion analysis. This study has attempted to evaluate and compare the distribution of bite force in complete denture by digital occlusion analysis without the need for conventional clinical remounting procedure.

2. Methods

Our observational clinical trial was conducted in the Department of Prosthodontics, Crown and Bridge, with ethical approval from the Institutional Ethics Committee (No. 201/2023/IEC/TMDCH, Dt. 2.6.23). Patients visiting the Prosthodontics OPD for complete denture rehabilitation were recruited after screening for systemic health and obtaining informed consent.

Inclusion criteria involved completely edentulous patients over 40 years with adequate or resorbed ridges (without undercuts) and sufficient bone height. Only those who declined implant overdentures and had no systemic illnesses or harmful habits were included. Exclusion criteria were systemic diseases, oral pathologies, bruxism, caregiver dependence, chronic smoking, flabby ridges, ridge undercuts, and immunocompromised conditions.

Complete denture fabrication:

Preliminary impressions were made using alginate, and diagnostic casts were poured with impression plaster. Custom trays (DPI Cold Cure RR) were fabricated, followed by conventional border moulding using low-fusing compound (DPI Pinnacle Tracing Stick), and final impressions with light-body PVS (Zhermack Elite HD+) using the selective pressure technique. Master casts were poured with Type 3 gypsum (Kalabhai – Kalstone), and split casts with die stone (Kalabhai – Labstone Type 4). Self-cure acrylic (DPI RR) was used for denture bases; occlusion rims were made using modelling wax (Cavex Set Up Hard). Jaw relations were recorded.



The occlusal plane was established parallel to Camper's plane. Facebow transfer (Hanau Springbow) and indirect transfer to a semi-adjustable articulator (Hanau Whip Mix) were performed. Vertical jaw relation was transferred, and extraoral Gothic arch tracers were used to record centric relation. The articulator was programmed using protrusive records. Anatomic teeth (Presto-Rock, New India) were arranged in bilateral balanced occlusion. After wax try-in, the dentures were processed with heat-cured PMMA (Heracryl, Surana Industries) by compression moulding to preserve occlusal vertical dimension. Lab remounting ensured occlusal balance; clinical remounting was omitted due to its complexity.

Lab remount

To address processing errors, a laboratory remount was done before denture insertion. Using the centric relation record, the mandibular cast was mounted against the maxillary cast. Occlusal contacts were evaluated in centric using 40-micron articulating paper to detect high points. Premature contacts, especially on non-supporting cusps, were adjusted with a fine-grit acrylic bur. Emphasis was placed on maintaining centric holding cusps (maxillary lingual, mandibular buccal) for occlusal stability. Lateral and protrusive interferences were also eliminated. Once bilateral balanced occlusion was verified, the dentures were polished and delivered.

Recording of bite force distribution

After 24 hours of denture insertion, patients were recalled to relieve sore areas. Bite force distribution was recorded using OccluSense^[15]. It's connected via Wi-Fi to an iPad, provided real-time data through the OccluSense app. It displayed bite force distribution and percentage in a color-coded map (red for high pressure, green for low), enabling quadrant-specific occlusal analysis and identification of high contacts.

Selective grinding after occlusense record

High-pressure zones were identified both on the app and directly on the denture teeth (via the sensor acting as articulating paper). These points were corrected using selective grinding. Premature balancing or strong working contacts were selectively reduced, preserving centric cusps. Adjustments were made to inclines and cusp tips to achieve simultaneous working and balancing

contacts. Anterior interferences were corrected by reshaping upper incisal lingual and lower labial surfaces. After adjustment, occlusion was reassessed with OccluSense and compared with baseline data (Figure 1).

Statistical analysis

Data analysis was done using SPSS version 25. Data entry was followed by normality testing via Shapiro-Wilk and Kolmogorov-Smirnov tests. Descriptive statistics summarized frequency and percentages. As data were normally distributed, paired t-tests were used for within-group comparisons (left and right side), and independent t-tests for between-group comparisons. A p-value <0.05 was considered statistically significant.

3. Results

Descriptive statistics were used to summarize the demographic characteristics of the participants, including age and sex. The Kolmogorov-Smirnov test was performed to assess the normality of the data. Since the data met the assumption of normality, a paired t-test was applied to compare the differences in bite force measurements before and after selective grinding.

The majority of the study participants (60%) were in the 50–60 years age group, while the remaining were evenly distributed between the 61–70 years (20%) and 71–80 years (20%) age groups (Table 1).

The study comprised 60% male and 40% female participants, indicating a higher representation of males (Table 2).

The One-Sample Kolmogorov-Smirnov (K-S) test was conducted to assess the normality of bite force distribution on both the left and right sides before and after selective grinding. On the left side, the mean bite force increased from 46.10 (baseline) to 48.30 (after selective grinding), while on the right side, it decreased from 53.90 (baseline) to 51.70 (after selective grinding). The standard deviation was lower after selective grinding on both sides (1.947) compared to baseline (2.961), indicating reduced variability. The Kolmogorov-Smirnov Z values were 0.694 and 1.077, with p-values of 0.721 and 0.197, respectively, on both sides. As the p-values were greater than 0.05, the data followed a normal distribution (Table 3).



A paired t-test was then employed to compare bite force measurements at baseline and after selective grinding on both the left and right sides. On the left side, the mean bite force increased from 46.10 ± 2.961 at baseline to 48.30 ± 1.947 after selective grinding. Conversely, on the right side, the mean bite force decreased from 53.90 ± 2.961 at baseline to 51.70 ± 1.947 after selective grinding (Figure 2) (Table 4).

The paired t-test analysis revealed a significant change in bite force distribution after selective grinding. On the left side, the bite force increased by 2.20 ($p = 0.005$, 95% CI: 0.86 to 3.54), while on the right side, the bite force decreased by 2.20 ($p = 0.004$, 95% CI: -3.54 to -0.86). These results indicate that selective grinding effectively redistributed occlusal forces (Table 5).

The Mann-Whitney U test showed no statistically significant differences in bite force between males and females in complete denture wearers, both at baseline and after selective grinding. At baseline, males had slightly higher mean ranks on the left side (5.67 vs. 5.25) and slightly lower on the right (5.33 vs. 5.75), with p-values of 0.91 and 0.83, respectively. After selective grinding, males had higher mean rank on the left (6.00 vs. 4.75), and females on the right (6.25 vs. 5.00), but p-values (0.50 left, 0.61 right) remained non-significant. Thus, gender had no significant effect on bite force distribution (Table 6).

Analysis of bite force variations in complete denture wearers before and after selective grinding across different age groups using the Kruskal-Wallis test. At baseline, bite force differences on both left and right sides were observed, but the p-value (0.264) indicated no significant variation. After selective grinding, changes in mean ranks were noted, with the 71–80 years group showing the highest bite force on the left side and the 61–70 years group on the right. However, the p-value (0.33) remained statistically not significant, suggesting that age did not significantly influence the effects of selective grinding (Table 7).

4. Discussion

The primary goal of this study was to assess the effectiveness of selective grinding using the OccluSense system in redistributing bite force in complete denture wearers. Our findings indicate a statistically significant change in bite force distribution following selective

grinding, with an increase in force on the left side and a corresponding decrease on the right. This suggests that selective grinding, guided by digital occlusal analysis, can enhance occlusal balance in complete dentures.

Previous literature highlights the role of balanced occlusion in improving denture function and patient comfort, especially in the elderly^[16]. The use of computer-aided tools such as OccluSense adds precision to occlusal adjustment by providing real-time visualization of contact areas and force distribution^[17,18].

OccluSense employs a 60-micron thick pressure-sensitive sensor that records occlusal contacts and also marks them using articulating ink, thereby combining the functions of visual marking and force analysis in one step^[19]. This is an advantage over systems like T-Scan, which require separate procedures for marking and digital evaluation and are significantly more expensive^[20].

In this study, gender and age did not show statistically significant differences in bite force, either at baseline or after selective grinding. This suggests that the response to occlusal equilibration is consistent across these demographic groups. Our findings are consistent with previous studies that also reported minimal influence of age or gender on occlusal force in complete denture wearers^[21,22].

Balanced occlusion achieved through selective grinding may also stimulate mechanoreceptors in the oral mucosa, partially restoring the occlusal sense lost due to edentulism^[23]. This enhanced neuromuscular response could explain the improved occlusal stability and patient satisfaction observed in this study.

A notable strength of this study is the integration of a digital occlusion system into routine prosthodontic workflow, reducing the reliance on time-consuming clinical remount procedures. Clinical remounting, while effective, often adds to treatment time and may not be well tolerated by elderly patients^[24]. OccluSense provides a practical alternative that reduces patient chairside time without compromising accuracy.

However, the study has some limitations. The sample size was modest, and long-term follow-up to assess occlusal stability over time was not performed. Moreover, only static occlusal contacts were evaluated,



without considering dynamic occlusal function during mastication.

In the context of existing literature, this study supports the use of digital occlusal analysis as an efficient alternative to conventional clinical remounting, especially in settings where patient compliance and time are critical factors. Future research should include longitudinal assessments, larger sample sizes, and comparisons with other digital systems like T-Scan or Dental Prescale.

Conclusion

The Study demonstrated that digital bite force evaluation using OccluSense, followed by selective grinding, significantly improves bite force distribution in complete denture patients without the need for complex remounting procedures. While no major differences were seen between sides, genders, or age groups, the approach enhanced masticatory efficiency, reduced post-insertion adjustments, and improved patient comfort and satisfaction. Further research is recommended to validate these findings across broader populations and prosthetic treatments.

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TABLE 1: AGE DISTRIBUTION OF THE STUDY PARTICIPANTS

	FREQUENCY (N)	PERCENTAGE (%)
50-60	6	60
61-70	2	20
71-80	2	20

TABLE 2 : GENDER DISTRIBUTION OF STUDY PARTICIPANTS

GENDER	FREQUENCY(N)	PERCENTAGE(%)
Male	6	60%
Female	4	40%

TABLE 3: ONE-SAMPLE KOLMOGOROV-SMIRNOV TEST

	Left side		Right Side	
	Baseline	After Clinical occlusal equilibration	Baseline	After Clinical occlusal equilibration
N	10	10	10	10
Mean	46.10	48.30	53.90	51.70
Normal Parameters ^a				
Std. Deviation	2.961	1.947	2.961	1.947
Absolute Most Extreme Difference	.219	.340	.219	.340
Positive	.152	.191	.219	.340
Negative	-.219	-.340	-.152	-.191



Kolmogorov-Smirnov Z	.694	1.077	.694	1.077
P value	.721	.197	.721	.197

a. Test distribution is Normal.

TABLE 4: COMPARISON OF BITE FORCE IN COMPLETE DENTURE WEARERS AT BASELINE & AFTER SELECTIVE GRINDING

BITE FORCE IN COMPLETE DENTURES		MEAN	STD. DEVIATION	STD. ERROR MEAN
Left side	Baseline	46.10	2.961	0.936
	After Clinical occlusal equilibration	48.30	1.947	0.616
Right side	Baseline	53.90	2.961	0.936
	After Clinical occlusal equilibration	51.70	1.947	0.616

TABLE 5 : PAIRED T-TEST ANALYSIS OF BITE FORCE IN COMPLETE DENTURE WEARERS

BITE FORCE IN COMPLETE DENTURES	MEAN DIFFERENCE	95% CONFIDENCE INTERVAL OF THE DIFFERENCE		T	Df	P value
		LOWER	UPPER			

Left Side	Baseline - After Selective grinding	-2.200	-3.540	-.860	-3.713	9	0.005*
Right Side	Baseline - After Selective grinding	2.200	.860	3.540	3.713	9	0.004*

TABLE 6: COMPARISON OF BITE FORCE DISTRIBUTION BETWEEN MALES & FEMALES IN COMPLETE DENTURE WEARERS

Bite force in complete dentures	Sides	Gender (N)	Mean rank	Sum of ranks	P value
Baseline	Left	Male (6)	5.67	34.00	0.91
		Female (4)	5.25	21.00	
	Right	Male (6)	5.33	32.00	0.83
		Female (4)	5.75	23.00	
After selective grinding	Left	Male (6)	6.00	36.00	0.50
		Female (4)	4.75	19.00	
	Right	Male (6)	5.00	30.00	0.61
		Female (4)	5.75	23.00	



		Female (4)	6.25	25.0 0	
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TABLE 7 : BITE FORCE ACROSS AGE GROUPS IN COMPLETE DENTURE WEARERS BEFORE AND AFTER SELECTIVE GRINDING

Bite force in complete dentures	Sides	Age groups (n)	Mean rank	P value
Baseline	Left	50-60 year (6)	6.00	0.264
		61-70 year (2)	2.50	
		71-80 year (2)	7.00	
	Right	50-60 year (6)	5.00	
		61-70 year (2)	8.50	
		71-80 year (2)	4.00	
After selective grinding	Left	50-60 year (6)	5.67	0.33
		61-70 year (2)	1.50	
		71-80 year (2)	9.00	
	Right	50-60 year (6)	5.33	
		61-70 year (2)	9.50	
		71-80 year (2)	2.00	

Figure 1: Bite Force Evaluation Using Occlusense.

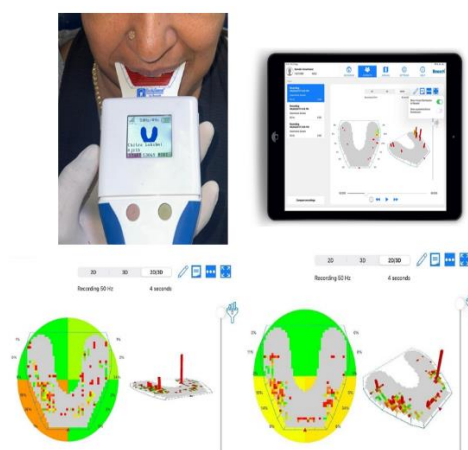


FIGURE 2: BITE FORCE COMPARISON BETWEEN BASELINE & AFTER SELECTIVE GRINDING

