

Evaluation of Masticatory Efficiency among subjects with Removable Partial Dentures: A Comparative Study

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Abstract

The aim of this study was to evaluate the masticatory efficiency of patients newly inserted with (1) RPDs in a single and/or both jaws against antagonist jaw and (2) Dentate Students (as Control Group).

A total of 107 RPDs patients, mean age 56.7 and 101 natural dentate students, mean age of 23.7, were included in this study. They were given 5.0g of peanuts to chew for 30s. During mastication the total Number of Strokes was recorded: (1) before and after insertion of RPDs group (w/ subgroups) and (2) Dentate Students (Control Group). Furthermore, masticatory efficiency was measured by Spectrophotometer LS-722N, at 590µm absorption rate. The measurements were taken (1) before inserting RPDs and three intervals after inserting RPDs (2) immediately after insertion of RPDs, (3) at one and (4) three months post insertion. The statistical significance was set at $P < 0.05$.

A statistically significant difference was found for masticatory efficiency between patients before and after insertion of RPDs in all the comparisons ($P < 0.0001$). Masticatory efficiency improved at three months post insertion of RPDs. Significant correlation was found between the number of strokes and masticatory efficiency three months post insertion of RPDs ($r = 0.387$, $P < 0.0001$). Higher masticatory efficiency was found in patients with antagonist natural teeth.

RPDs treatment does not reach the level of masticatory efficiency to completely restore function comparable to subjects with natural dentition. However, prosthetic rehabilitation with RPDs does significantly improve the ME, especially after three months of insertion.

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Introduction

Masticatory efficiency (ME) is considered to be an important parameter for objective evaluation of masticatory function. Mastication studies are of interest for dental professionals because mastication itself stimulates growth, development and maintains the health of stomatognathic system.¹ The ability to chew is not only an important aspect of oral health, but also increasingly accepted as being related to general health.² Masticatory efficiency is the

ability to grind food to achieve a standard particle rate for a given time.³ Furthermore, masticatory efficiency is often measured by determining an individual's ability to crush, or grind food.⁴

Reports suggest that masticatory efficiency is reduced by tooth loss. The number of teeth in the oral cavity and the loss of occlusal contacts are important factors that affect the action of the masticatory system.⁵ Yurkstas (1954), found a correlation between the loss of molar teeth and variation in the degree of masticatory performance and efficiency.⁶ Healthy teeth are a key factor in this process, especially the posterior teeth where food is fragmented. Fragmentation depends on the total surface that forms the occlusal surfaces and the number of teeth in occlusion.⁷ Keeping a reasonable number of natural teeth is the best way to guarantee adequate masticatory efficiency.⁸

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In the literature, several methods have been used for evaluating the ME e.g. fluctuation of the nutrition particles, tested by multi-sieve system, ultrasonography, spectrophotometry, optical scanning methods and measurement of the volume of masticatory muscle recorded by electromyography (EMG).⁹ None of the latter methods exceeds each other, therefore the option is complex as some tests are more time consuming. The Spectrophotometry provides a quick and effective means to evaluate masticatory efficiency.¹⁰

Rehabilitation of the oral function in edentulous patients can be achieved with fixed or removable prosthodontics. Removable Partial Dentures (RPDs) play an important role in restoring patients' oral masticatory function, aesthetics, including their systemic health. One of the most popular methods for replacement of missing teeth, since 1970, were RPDs, however increasing number of clinicians consider them as second choice treatment yielding to other treatment options.¹¹ Fueki K *et al.* stated that prosthetic restoration with RPDs may benefit objective ME in patients needing replacement of missing posterior teeth.¹² Replacing missing teeth with RPDs including short dental arches in particular provide a prerequisite for efficient chewing.¹³ However, masticatory efficiency is decreased by 40% in reduced dentitions and RPDs may only partially compensate this functional deficit.^{14,15} Overall researches suggest mixed data on the improvement of ME of dentate elderly patients by means of prosthetic rehabilitation.¹⁶

The key question is whether prosthetic rehabilitation of missing teeth can restore masticatory function at the level of subjects with healthy dentition. This was studied by many researchers, the majority focusing on evaluating ME on subjects with complete dentures.¹⁷ However, there is evidence that masticatory efficiency in patients restored with fixed and removable partial dentures has significantly improved.¹⁸

The aim of this study was to evaluate masticatory efficiency of patients inserted with (1) RPDs in a single and/or both jaws and compare them to the antagonist jaw with RPD subgroups: (1a) the Antagonist Remaining Natural Dentition, (1b) Antagonist Clapsed RPDs, (1c) Antagonist Fixed Dentures (1d) Antagonist Resin RPDs (1e) Antagonist Attachment retained RPDs compared

against each other and (2) Dentate Students (as Control Group).

Materials and methods

A total of n=107 patients with RPDs with mean age 56.7 (DS \pm 11.0) and n=101 Dentate Students with mean age 23.7 (SD \pm 3.8) were included in this study. The research proposal was accepted and approved by the Institutional Ethics Committee of the University Dentistry Clinical Center of Kosovo, Prishtina, Kosovo and a written consent was obtained from each individual subject.

Inclusion criteria were: (1) non-RPD wearer patients, with history of recent extractions no sooner than three months prior, no periodontal involvement of abutment teeth and no history of diabetes and/or TMJ disorders. (2) Residual ridges without any excessive undercuts with any redundant mucoperiosteum. (3) Angle class I jaw relationships and adequate inter-arch space to accommodate the RPDs.

The (convenience) sample was taken at the Department of Prosthodontics, Faculty of Medicine, Branch of Stomatology, University of Prishtina, Kosovo. The sample was divided into two experimental groups: (1) Patients inserted with RPDs in a single and/or both jaws w/ RPD subgroups: (1a) the Antagonist Remaining Natural Dentition (n=37), (1b) Antagonist Clapsed RPDs (n=23), (1c) Antagonist Fixed Dentures (n=22), (1d) Antagonist Resin RPDs (n=17), (1e) Antagonist Attachment retained RPDs (n=8), compared against each other and (2) Dentate Students, as a Control Group.

The response rate of the sample group was very high with only 5 patients in the RPDs group failing to turn out at three months post insertion of RPDs. It is worth noting that these patients were retained in the sample during statistical analysis.

Group (1) (RPDs) included a comparison of patient masticatory efficiency with RPDs against Dentate Students as a Control Group; Group (2) compared RPD patient's masticatory efficiency against antagonist jaws (RPDs subgroups: 1a, 1b, 1c, 1d, 1e).

Masticatory efficiency measurement methodology was followed as described by Changbin Fan *et al.*¹⁹

Masticatory efficiency measurement results are dependent on the type, size and

shape of food including the recorded number of strokes during mastication. Peanuts are primarily used with this method as they are relatively uniform in size which facilitates standardization and can be used without any previous preparation. The subjects were given 5.0g of peanuts to chew for 30s and were recommended to chew naturally, bilaterally, simultaneously counting the total number of strokes for the given period. At period, both the bolus and the denture(s) were disgorged, washed and then poured into a 1000 mL measuring cylinder. Water was added to dilute the extract to 1000 mL. The suspension was mixed for 1 minute and left for 2 minutes. With a graduation pipette, one third of the suspension was transferred into the spectrophotometry containers. The cell was measured by Spectrophotometer LS-722N (Shanghai, China) at 590 μm absorption rate. The observation measurements were repeated at one and three month intervals. Regular use of the RPDs by the patient, in all phases of the study, was a prerequisite for them to continue participation in study.

Data Analysis

Statistical analysis was performed using Statistical package for social sciences SPSS v.22. The data were subject to Kruskal-Wallis and Dunn's Multiple Comparison, Friedman and Wilcoxon matched pair's tests. The level of significance was set at P<0.05.

Results

	Patients group N =107	Dentate Students N=101
Gender,	N (%)	
F	49 (45.8)	61 (60.4)
M	58 (54.2)	40 (39.6)
	Age (years)	
Mean ± SD	56.7 ± 11.0	23.7 ± 3.8
Range	32 – 80	18 – 39

Table 1. Sample population demographics.

A total of 107 patients with RPDs with mean age of 56.7 (DS ± 11.0) (45.8% females) and 101 natural dentate students with mean age of 23.7 (SD ± 3.8) (60.4% females) were included in this study as a control group (Table 1). A total of 138 RPDs were examined, Clasp retained

RPDs were 87, attachment retained RPDs were 51. Maxillary RPDs were 66 and mandibular RPDs were 72.

Following statistical analysis of the data, when comparing the RPD Group vs. Dentate Students (control Group) there was statistically significant increase in Masticatory Efficiency between the groups at all measurement intervals, both before and after insertion (P <0.0001). However, Masticatory Efficiency was much better at three months post insertion of the RPDs (Table 2).

	Dentate Students N	Before RPDs 107	After RPDs 107	After one month RPDs 107	After three months RPDs 102	P-value*
Masticatory efficiency						
Mean ± SD	0.91 ± 0.14	0.30 ± 0.14	0.44 ± 0.14	0.56 ± 0.12	0.74 ± 0.12	P<0.0001
Range	0.64 - 1.22	0.04 - 0.66	0.17 - 0.89	0.27 - 0.98	0.45 - 1.00	
Kruskal-Wallis test#	KW=472.3, P<0.0001					

Table 2. Masticatory efficiency of Dentate Students (as Control Group) versus RPDs wearers.

*between group of patient before and after RPD with paired analysis.

#between group of students and patient at different times.

	Dentate Students N	Before RPDs 107	After RPDs 107	After one month RPDs 107	After three months RPDs 102	P-value*
Number of strokes						
Mean ± SD	46.1 ±	46.8 ± 8.9	47.5 ± 8.7	51.7 ± 7.7	55.1 ± 7.3	P<0.0001
Range	31 – 67	23 - 62	30 - 64	38 – 66	40 - 68	
Kruskal-Wallis test#	KW=98.7, P<0.0001					

Table 3. Number of strokes in Dentate Students (as Control Group) versus RPDs wearers.

*between group of patient before and after RPD with paired analysis.

#between group of students and patient at different times.

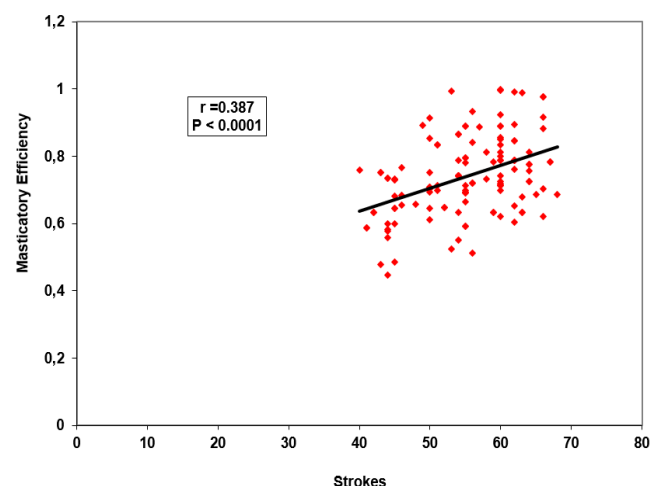


Figure 1. The correlation between the number of strokes and masticator efficiency three months after insertion the RPDs.

There was also a statistically significant increase in the Number of Strokes when comparing RPD Group vs. Dentate Students (Control Group) at all measurement intervals, both before and after insertion ($P < 0.0001$). Again, the Number of Strokes increased significantly at three months post insertion of the RPDs (Table 3). Further more, among RPDs Group three months post insertion of RPDs, statistically significant correlation was found between the Number of Strokes and Masticatory Efficiency ($r = 0.387$, $P < 0.0001$) (Figure 1) versus Dentate Students (Control Group) ($r = 0.579$, $P < 0.0001$) (Figure 2).

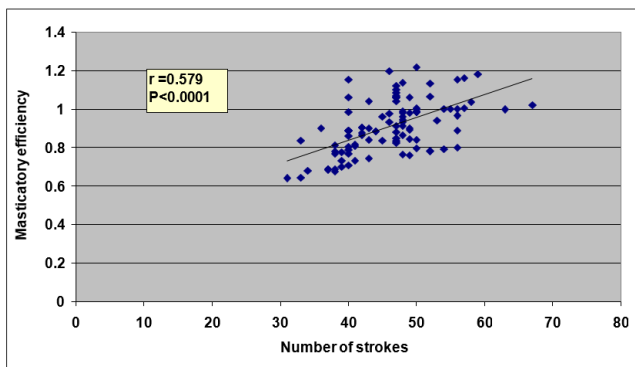


Figure 2. The correlation between the number of strokes and masticator efficiency of Dentate Students (as Control Group).

	Antagonist jaws (RPDs subgroups)					P-value
	Antagonist Remaining Natural Dentition	Antagonist Fixed Dentures	Antagonist Clasped RPDs	Antagonist Resin RPDs	Antagonist Attachment RPDs	
N	37	22	23	17	8	
Masticatory efficiency before insertion the RPDs						
Mean ± SD	0.38 ± 0.13	0.27 ± 0.12	0.29 ± 0.14	0.26 ± 0.12	0.22 ± 0.09	P=0.008
Range	0.19 - 0.66	0.05 - 0.56	0.04 - 0.51	0.07 - 0.52	0.14 - 0.48	
Masticatory efficiency after insertion the RPDs						
Mean ± SD	0.50 ± 0.14	0.44 ± 0.16	0.43 ± 0.13	0.39 ± 0.14	0.40 ± 0.07	P=0.049
Range	0.27 - 0.89	0.22 - 0.88	0.17 - 0.62	0.18 - 0.62	0.29 - 0.59	
Masticatory efficiency one month after insertion the RPDs						
Mean ± SD	0.61 ± 0.12	0.55 ± 0.16	0.56 ± 0.11	0.49 ± 0.13	0.55 ± 0.07	P=0.013
Range	0.35 - 0.90	0.32 - 0.98	0.33 - 0.72	0.27 - 0.69	0.46 - 0.68	
Masticatory efficiency three month after insertion the RPDs						
Mean ± SD	0.80 ± 0.12	0.73 ± 0.13	0.71 ± 0.08	0.64 ± 0.10	0.79 ± 0.08	P=0.0004
Range	0.58 - 1.00	0.45 - 1.00	0.59 - 0.87	0.48 - 0.81	0.71 - 0.98	

Table 4. Masticatory efficiency before, immediately, one and three months after insertion the RPDs, versus antagonists (RPDs subgroups).

When comparing the RPD subgroups against their antagonists, we found statistically significant increase in Masticatory Efficiency before insertion of the RPDs ($P = 0.008$). Evidently Masticatory Efficiency was higher in patients with

antagonist natural teeth at all measurement intervals post insertion of RPDs (Table 4).

Discussion

The physiological and biophysical aspects of natural mastication in humans play an important role in the natural development of the stomatognathic system. Since early 20th century, numerous studies have been carried out to investigate the masticatory efficiency and its importance.²⁰ Mastication depends on several factors including movements of mandible, tongue movements, masticatory muscle activity and occlusal forces. However, it is not yet decided which is the most important.²¹

Removable Partial Dentures increase bolus particle reduction, failing to fully restore masticatory efficiency.^{22,23} Few studies have shown that subjects restored with RPDs demonstrate lower ME indexes versus subjects with complete and healthy dentitions or fixed dentures.^{24,25} Higher masticatory efficiency in younger subjects may be attributed to higher adaptability, maximum bite force, and neuromuscular coordination as in contrast to elderly subjects.²⁶ However, these references contradict earlier studies stating no association between age and masticatory efficiency.^{27,28}

Our results show that RPDs patients had decreased masticatory efficiency compared to Dentate Students as a control group. Treatment with RPDs improved ME and was observed before and after insertion of the RPDs, however the greatest improvement was observed at 3 months following the insertion. Masticatory Efficiency in natural dentition is the best beyond discussion.²⁹ Patients with natural dentitions had the highest ME versus patients with conventional and implant-supported complete dentures, respectively.^{30,31}

Several studies conclude that denture wearers on an average need 4–8 times the number of chewing strokes of dentate persons to achieve the same degree of pulverization. It was also found that the chewing efficiency of denture wearers also depends on the consistency of the food, with considerable variation between studies.^{32,33} Mendonca D B *et al.* demonstrated that masticatory efficiency after 40 chewing strokes was better, suggesting that individuals should execute more chewing strokes to exert maximum results.^{34,35} Furthermore we confirmed

that masticatory efficiency of RPDs wearers improved with increased number of masticatory strokes within a 30 second interval. In addition, the number of strokes increased from the moment of RPDs insertion at all measured intervals. Although, this ratio provides a measurement of performance of the dentition, it fails to define the point of impairment.³⁶

We also compared ME of patients with RPDs versus their antagonists. Evidently, the highest ME had RPDs subjects (subgroup a1) with Antagonist Remaining Natural Dentition. Literature reviews report that ME is closely related to the number of remaining natural teeth.³⁷ Specifically, some studies suggest that the existence of occlusal support of teeth is crucial for masticatory function which is consistent with the accepted concepts of mastication by clinicians.^{38,39}

Muslita *et al.* concluded that a high number of an occluding pairs of teeth-functional tooth unit 7.5 improves masticatory performance, while subjects with 2.9 a functional tooth unit have poor masticatory performance.⁴⁰ According to Naka *et al.*, dentures are recommended to increase the number of an occluding pairs of teeth in patients with fewer than three a functional tooth unit for a satisfactory ME.⁴¹ It may be supposed that every study included subjects with various numbers of occluding pairs of teeth, but each is still only valid for certain populations.

Most researchers exclude from their ME studies RPDs subjects due to a wide variety of possible tooth combinations and toothless areas of partial dentures that, more or less, complicate the prosthesis design. On the contrary, Yamashita *et al.* suggested that including RPDs in the studies was important to maintain ME based on the presence of occluding unit of functional tooth, regardless of RPDs classification.⁴²

A further limitation of this study includes non-randomized group allocation and short follow up period, unlike the other studies that followed for 6,12,18 and 36 months, respectively after insertion of RPDs. [12,13,19] within these limitations, we emphasize that prosthetic restoration with RPDs may provide benefit in terms of objective evaluation of ME in patients needing replacement of missing teeth.

Conclusions

Patient rehabilitation with RPDs improved their masticatory efficiency, however failing to completely restore masticatory function at the level of subjects with natural dentition.

The reduced function of the masticatory system due to loss of posterior teeth without occlusal contact may be significantly improved with the rehabilitation of subjects with RPD and recover ME. From our results, it was suggested that the occlusal state affected the masticatory efficiency of elderly patients. However, these data will serve clinicians to make informed clinical decisions and objectively predict future treatment outcomes. Longitudinal and systematic clinical studies are recommended to further complement these results.

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Declaration of Interest

The authors confirm that this article content has no conflict of interest.

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