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Original Article

Masticatory efficiency improved with mini dental implant retained lower complete dentures.

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Abstract

Background Edentulous patients with severe bone loss encounter lower complete denture (L-CD) instability problems. Mini dental implant (MDI) retained L-CDs are an alternative treatment for unstable L-CD patients. This study subjectively and objectively evaluated masticatory efficiency before and after MDI retained L-CD treatment.

Materials and methods The subjects received 4 MDIs in the anterior mandible to retain their L-CD. Masticatory efficiency was evaluated after using their L-CD at least 3 months prior to MDI placement, 1 month after L-CD loading, and 3 months after L-CD loading. The subjective evaluation used a four-point rating scale questionnaire to assess chewing performance to generate the "Perceived Chewing Ability Score" (PCAS). The objective evaluation used a two-colored wax cube analysis method, determining the "Percentage of Chewing Ability" (PCA).

Results The median PCAS and mean PCA values increased through Tests 1, 2, and 3. There were significant differences ($p \leq 0.001$) between before and after MDI retained L-CD treatment in both evaluations.

Conclusions All L-CD patients subjectively and objectively improved their masticatory efficiency after MDI placement. Our results suggest that minimally invasive MDI treatment is an attractive option for patients with L-CD instability problems, leading to improved masticatory efficiency and quality of life.

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Key words: *elderly patients; implant retained lower complete dentures; masticatory efficiency; mini dental implant, quality of life*

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Introduction

The standard treatment of complete edentulism is a conventional complete denture. However, severe bone resorption in the mandible causes a lack of lower complete denture (L-CD) retention and stability, leading to impaired chewing ability, and decreased quality of life (Tallgren, 1972). Using two standard size implants to retain an L-CD can provide improved denture retention, stability, and comfort (Feine, 2002). However, there are limitations for standard size implant treatment e.g. inadequate bone at the implant placement site, medically compromised elderly patients, cost, and being time-consuming. Minimal invasive treatment with Mini Dental Implants (MDIs) is an alternative treatment to retain unstable L-CDs (Shatkin and Shatkin, 2003). MDIs are one-piece titanium alloy implants with a diameter less than 3 mm, typically ranging from 1.8-2.9 mm. A MDI can be placed where there is insufficient bone for standard size implants, without additional procedures such as bone grafts (Preoteasa, et al., 2010). The MDI placement procedure is simpler and quicker compared with wider-diameter implants (Flanagan and Mascolo, 2011). MDIs can be placed with or without raising a flap and can be immediately loaded with a denture if sufficient primary stability is achieved. Moreover, MDIs are a cost-effective implant treatment (Ahn, et al., 2004). Minimally invasive MDI treatment can be performed in patients with relative contraindications to standard size implant treatment, including reduced ridge width, systemic problems, and elderly patients (Flanagan and Mascolo, 2011). Initially, MDIs were used for transitional prosthetic stabilization and were approved for long-term use by the United States Food and Drug Administration in 2003 (United States Food and Drug Administration, 2003; Christensen, 2006; Bidra and Almas, 2013). Several studies demonstrated the high long-term performance of MDIs in denture stabilization with a more than 90% survival rate, depending on the methodology and survival criteria of each study (Griffitts, et al., 2005; Shatkin et al., 2007; Morneburg and Proschel, 2008). The minimum number of MDIs required for retain a complete denture is six in the maxilla and four in the mandible (Flanagan and Mascolo, 2011).

Prosthesis treatment aims to restore chewing ability to maintain a patient's dietary intake, resulting in improved general health and quality of life (Takata et al., 2006). Thus, masticatory efficiency is a significant indicator in the success of dental treatment and improvement in quality of life. The measurement of masticatory efficiency can be divided into two categories, subjective and objective evaluations. The subjective evaluation refers to data obtained from patients' self-reports such as an interview or questionnaire. In Thailand, a four-point rating scale questionnaire of 14 common Thai foods was developed to evaluate patients' chewing ability (Kunon and Kaewplung, 2014). The objective evaluation is based on data obtained from quantitative analysis. In Thailand, a two-colored wax cube analysis method was developed (Prapatrungsri, et al., 2010) and is a method for the evaluation of denture wearers' chewing ability (Prapatrungsri, et al., 2010; Liangbunyaphan et al., 2011; Liangbunyaphan et al., 2012; Chokpreecha and Kaewplung, 2013; Kunon and Kaewplung, 2014).

The objective of this study was to evaluate masticatory efficiency before and after MDI retained L-CD treatment subjectively using the questionnaire and objectively using the two-colored wax cube analysis.

Materials and methods

Subject population

All subjects were recruited into this study using the following inclusion criteria

- Functional retention and stability problems with their L-CD.

- The upper dentition had good posterior support composed of all natural teeth, partially edentulous, or completely edentulous with any type of prosthesis such as conventional complete denture (CD), acrylic or metal removable partial denture (RPD) or fixed partial denture (FPD).

- The conventional lower complete denture was acceptable in quality and occlusion. While the conventional upper denture was acceptable in quality, occlusion and function.

- The subjects had worn their dentures for 3 months or longer prior to participating in the study. The condition of the denture is pass the standard for complete the case.

- The subjects could not undergo the surgical procedure of the standard size implant retained L-CD because of severe resorption of the mandible (insufficient bone width), poor general health, or too costly.

- The bone in the implant placement area was at least 3 mm wide, 12 mm high, and had bone density classified as D1-D3 according to Misch's bone classification (Misch, 1990).

- The subjects were healthy or had a controllable systemic disease, were in ASA physical status classification I or II, and had no medical condition contraindicating implant surgery.

- No psychological or psychiatric conditions that could influence treatment or the study.

The study protocols were approved by the Ethics Committee of the Faculty of Dentistry, Chulalongkorn University, and written informed consent was obtained from each subject after a full explanation of the clinical trial.

Radiographic examination

The subjects had the quality and quantity of the bone site for implant placement evaluated by panoramic radiograph and cone beam computed tomography (CBCT) with a surgical stent.

The bone height determined from the CBCT was classified using the minimum vertical bone height of the residual mandible according to The American College of Prosthodontists (ACP) (McGarry, 1999). The subjects were classified into two groups according to a modification of the ACP classification as the High bone group (ACP type I/II: a minimum vertical bone height > 15 mm) and the Low bone group (ACP type III/IV: a minimum vertical bone height ≤ 15 mm).

To classify the bone width from the sagittal view of the CBCT, the minimum bone width of the residual mandible was classified into two groups depending on the minimum bone width required for standard size implant placement (5 mm) as the Wide bone group (bone width ≥ 5 mm) and the Narrow bone group (bone width < 5 mm) (Preoteasa, et al., 2010).

Surgical and prosthetic procedures

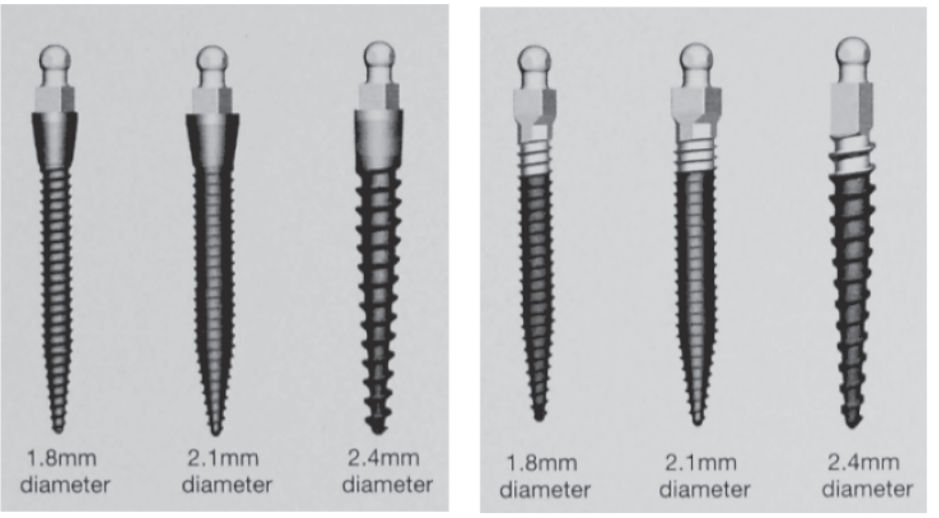
The MDIs were selected for each individual subject by diameter, length, and type of fixture according to the manufacturer's instructions (3M ESPE, USA). The MDIs used in this study had diameters of 1.8, 2.1, or 2.4 mm and lengths of 10, 13, or 15 mm. O-ball implants with a collar were used with thick attached gingiva (≥ 2 mm) (Fig. 1a) and O-ball implants without a collar were used with thin attached gingiva (< 2 mm) (Fig. 1b).

The MDI surgical procedures were performed by surgeons and postgraduate students from the Oral and Maxillofacial Surgery Department of the Faculty of Dentistry, Chulalongkorn University. A surgical stent was used to guide the position and direction of the MDI placement. Each subject received 4 MDIs in the interforamen area of the mandible. Immediate loading of the L-CD was done if the implants had good primary stability with a minimum torque of 35 Ncm. If

the torque was lower than 35 Ncm, loading the L-CD was delayed for 4-6 month, and soft liner (SECURE Soft Reline Kit, 3M ESPE, USA) was used to reline the denture for its function during this time. The L-CD was fit to the ball attachments with metal housings and O-rings by an intra-oral technique using a hard acrylic pick-up method (SECURE Hard Pick-Up Kit, 3M ESPE, USA) (Fig. 2a, 2b).

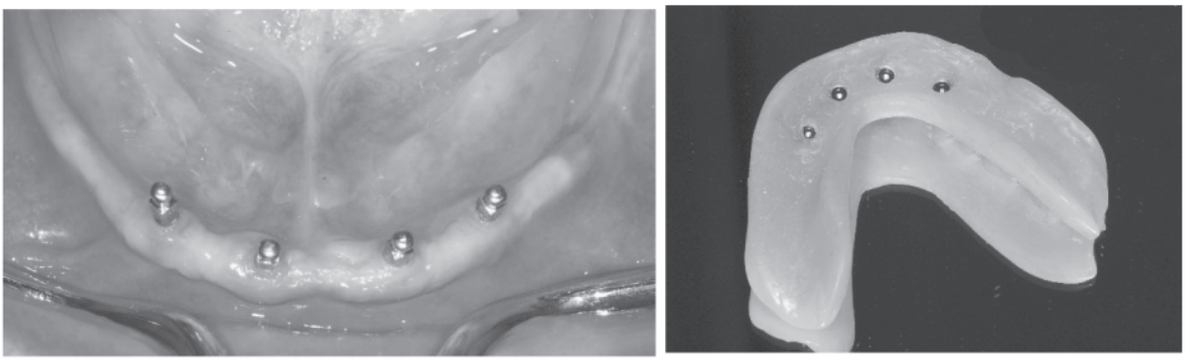
Masticatory efficiency evaluations

The masticatory efficiency of the subjects were assessed subjectively and objectively at each of 3 tests: Test 1: after using the L-CD for more than 3 months before MDI placement, Test 2: after loading the L-CD for 1 month, and Test 3: after loading the L-CD for 3 months.



1a 1b

Fig. 1 MDIs (3M ESPE, USA).
a) O-ball implants with a collar.
b) O-ball implants without a collar.



2a 2b

Fig. 2 The MDI retained L-CD.
a) The Intraoral view of the 4 MDIs.
b) The tissue surface of the L-CD after picking up the O-rings.

1. *Subjective masticatory evaluation*

The subjects were interviewed to evaluate their subjective chewing ability using a self-reported questionnaire developed in our previous study (Kunon and Kaewplung, 2014). The self-reported questionnaire consisted of 14 common food types in Thailand: Porridge, Chinese Vegetable Stew, Chinese Cabbage Soup, Steamed Rice, Noodle Soup, Omelet, Steamed Fish, Sour Curry, Banana, Fried fish, Orange, Fresh Guava, Fried pork, and Stir-fried Vegetables. The subjects were asked to rate their chewing ability for each food type using a four-point rating scale ranging from 0 points (could not chew at all) to 3 points (could chew well) (Fig. 3). All the interviews were conducted by the same examiner.

The total score of these 14 food types (ranging from 0-42) was calculated as the "Perceived Chewing Ability Score" (PCAS) of each subject, with higher scores indicating better masticatory efficiency. The improvement in masticatory efficiency after MDI treatment was calculated as the percentage change of the PCAS using the following formula:

$$\text{Percentage change of the PCAS} = \frac{(\text{Test 3 score} - \text{Test 1 score}) \times 100}{42}$$

2. *Objective masticatory evaluation*

After the subjective chewing test, the subjects masticatory efficiency was objectively assessed using the wax cube analysis method as previously described (Prapatrungsri, et al., 2010; Liangbunyaphan et al., 2011; Liangbunyaphan et al., 2012; Chokpreecha and Kaewplung, 2013; Kunon and Kaewplung, 2014). The images of the chewed wax pieces were captured using a digital camera (Nikon D80, Nikon Corporation, Tokyo, Japan) with a macro lens (Sigma macro 105 mm) under standardized distances and light conditions. Eight digital images per subject (the upper and lower sides of the 4 pieces of chewed wax) were obtained

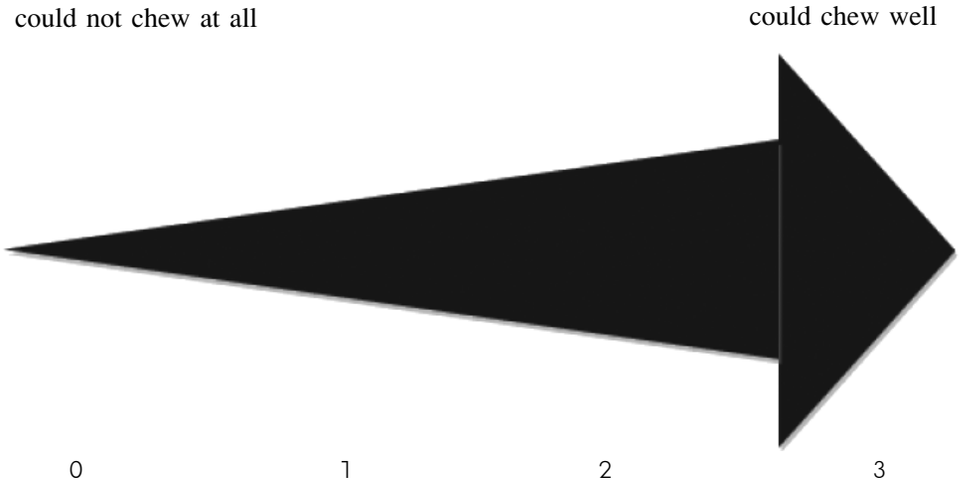


Fig. 3 The four-point rating scale for each food type.

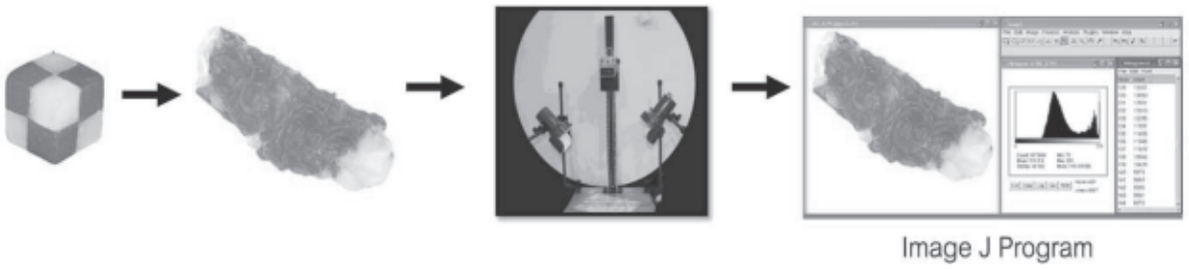


Fig. 4 The Chewed wax cube analysis method.

from each test. The images of the chewed wax were transferred and analyzed using the Image J program (Version 1.42Q, NIH, MD, USA) (Fig. 4)

The standard color value was determined using a well-mixed red and white wax cube, resulting in a homogeneous orange color. Then the image of the standard mixture was captured and analyzed by the Image J Program.

After each test, the average value of the degree of mixing of the white and red wax was calculated as the average "Percentage of Chewing Ability" (PCA) by the following formula:

$$\text{The PCA} = \frac{\text{Total number of pixels of standard color} \times 100}{\text{Total number of pixels of the chewed wax}}$$

Repeating the analysis for all the chewed wax images with the Image J Program for all subjects in Test 1 assessed the test-retest reliability of this objective evaluation.

The improvement in chewing ability after treatment with MDIs was calculated as the percentage change of the PCA using the following formula:

$$\text{Percentage change of the PCA} = \frac{(\text{Test 3 score} - \text{Test 1 score}) \times 100}{100}$$

The schematic of the methodology of our study is shown in Fig. 5.

Statistical analysis

The data was analyzed using the SPSS program version 17.0 (SPSS [Thailand] Co., Ltd., Bangkok, Thailand). The Friedman and Wilcoxon signed ranks tests were used to compare the values of the PCAS between the 3 tests. One way repeated measures analysis of variance (ANOVA) was assessed to compare the values of the PCA between the 3 tests. The normality of the data distribution was tested using the one sample Kolmogorov-Smirnov test. The influence of sex, ASA physical status classification, mandibular bone height, and width on the results were tested using the independent t-test or Mann-Whitney U test depending on data distribution. The effect of age and type of upper dentition was tested using One-way analysis of variance (ANOVA) or Kruskal-Wallis test depending on data distribution and homogeneity of variance. The test-retest reliability of the two-colored wax cube analysis method by the image J program was investigated by the Reliability analysis. The relationship between subjective and objective chewing ability was demonstrated using Pearson's correlation analysis.

Results

The 33 subjects consisted of 10 males and 23 females ranging in age from 55-83 years old with a mean age of 67.50 ± 7.66 years. Twenty-five subjects (75.76%) had totally edentulous upper and lower arches, and wore upper and lower CDs. Seven subjects (21.21%) retained some natural teeth in their upper arch, both anterior and posterior teeth, and wore upper RPDs. Only one subject (3.03%) had upper natural teeth with an FPD.

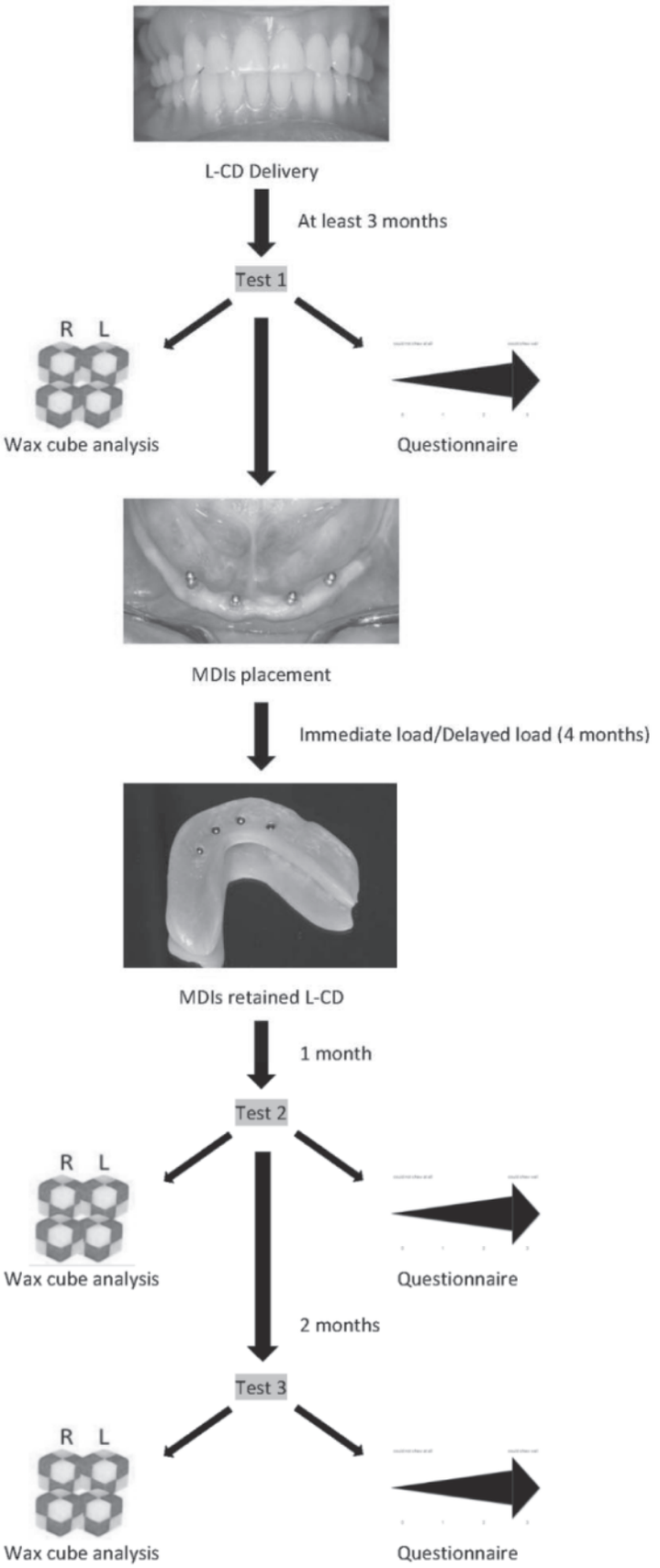


Fig. 5 The schematic of the methodology.

The masticatory efficiency in Test 1, Test 2 and Test 3 as assessed subjectively and objectively were compared. In the subjective evaluation, the subjects rated their PCAS at 20 ± 5.93 in Test 1 that increased to 40 ± 2.03 in Test 2 and 41 ± 1.82 in Test 3. By the objective evaluation, the mean PCA was 19.22 ± 3.75 in Test 1 and increased to 29.7 ± 4.79 in Test 2 and 31.02 ± 3.70 in Test 3. The median and standard deviations of the PCAS, the mean and standard deviations of the PCA of all 3 Tests, and the percentage change of PCAS and PCA between Test 1 and Test 3 are presented in Table 1.

The subjects' masticatory efficiency evaluated by age, sex, type of upper prosthesis, general health status by ASA Classification, the minimum vertical bone height, and the minimum bone width of the mandible are shown in Tables 2 and 3. Statistical analysis revealed that there were no significant differences in the measurement outcomes between males and females, the four age groups, the two ASA classifications, the three types of upper prosthesis, the High bone group and the Low bone group or the Wide bone group and the Narrow bone group ($p > 0.05$).

Table 1. The perceived chewing ability scores (PCAS) and the percentage of chewing ability (PCA) obtained from the 3 tests and the percentage change in PCAS and the percentage change in PCA from Test 1 to Test 3 (n=33).

	Test 1	**Test 2**	**Test 3**	**Percentage change** (mean ± sd)
PCAS (median ± sd)	20 ± 5.93	40 ± 2.03	41 ± 1.82	45.60 ± 13.50
PCA (mean ± sd)	19.22 ± 3.75	29.61 ± 4.79	31.02 ± 3.70	11.80 ± 2.90

a denotes statistical difference at $p<0.001$

b denotes statistical difference at $p<0.05$

Table 2. The median and standard deviation of the PCAS in Test 1, Test 2, and Test 3. The mean and standard deviation of the percentage change of the PCAS shown by age, sex, ASA Classification, type of upper prosthesis, bone height, and bone width.

Characteristics	N (%)	The Percentage of Chewing Ability (PCA)			
		Test 1	Test 2	Test 3	percentage change
Age (years)					
<60	1 (3.03)	24 ± 0.00	39 ± 0.00	41 ± 0.00	40.48 ± 0.00
60-69	16 (48.48)	20 ± 5.22	41 ± 1.86	41 ± 1.82	40.36 ± 11.97
70-79	15 (45.45)	22 ± 6.90	40 ± 2.23	40 ± 1.78	43.97 ± 15.92
>80	1 (3.03)	26 ± 0.00	40 ± 0.00	41 ± 0.00	35.71 ± 0.00
Sex					
Male	10 (30.30)	20.5 ± 6.28	39.5 ± 1.70	41 ± 1.51	45.71 ± 15.01
Female	23 (69.70)	21 ± 5.70	40.5 ± 2.07	41 ± 1.87	44.91 ± 13.09
ASA Classification					
ASA I	12 (36.36)	20 ± 5.78	40 ± 2.22	41 ± 2.02	47.82 ± 13.18
ASA II	21 (63.64)	22 ± 6.10	40 ± 1.97	41 ± 1.74	44.33 ± 13.83
Type of Upper Prosthesis					
CD	25 (75.76)	20 ± 5.63	40 ± 1.59	41 ± 1.58	46.00 ± 13.22
RPD	7 (21.21)	24 ± 6.23	39 ± 2.64	40 ± 2.14	42.18 ± 13.92
FPD	1 (3.03)	12 ± 0.00	36 ± 0.00	37 ± 0.00	59.52 ± 0.00
Modified Bone height					
High bone group	20 (60.60)	20 ± 6.23	40 ± 2.16	41 ± 1.73	47.02 ± 14.63
Low bone group	13 (39.40)	21 ± 5.61	40 ± 1.88	40 ± 1.98	43.41 ± 11.75
Modified Bone width					
Wide bone group	19 (57.58)	20 ± 6.58	40 ± 2.12	41 ± 2.06	45.24 ± 14.57
Narrow bone group	14 (42.42)	20.5 ± 5.14	40 ± 1.94	40.5 ± 1.50	45.92 ± 12.23

Table 3. The mean and standard deviation of the PCA in Test 1, Test 2, and Test 3. The mean and standard deviation of the percentage change of the PCA shown by age, sex, ASA Classification, type of upper prosthesis, bone height, and bone width.

Characteristics	N (%)	The Percentage of Chewing Ability (PCA)			
		Test 1	Test 2	Test 3	percentage change
Age (years)					
<60	1 (3.03)	19.58±0.00	25.16±0.00	31.69±0.00	12.11±0.00
60-69	16 (48.48)	18.33±3.61	29.80±4.29	30.77±3.47	12.44±3.35
70-79	15 (45.45)	20.04±4.04	29.90±4.45	31.60±3.80	11.56±2.22
>80	1 (3.03)	20.89±0.00	26.71±0.00	29.63±0.00	8.74±0.00
Sex					
Male	10 (30.30)	18.60±3.42	28.11±2.60	29.99±1.89	11.39±3.23
Female	23 (69.70)	19.69±3.89	30.54±4.65	31.84±3.90	12.15±2.72
ASA Classification					
ASA I	12 (36.36)	19.22±2.65	30.20±3.95	31.40±4.03	12.18±3.23
ASA II	21 (63.64)	19.22±4.31	29.28±4.50	30.80±8.58	11.58±2.75
Type of Upper Prosthesis					
CD	25 (75.76)	19.30±3.53	29.70±4.09	31.15±3.28	11.85±3.05
RPD	7 (21.21)	19.54±4.34	30.05±4.68	31.69±4.03	12.16±2.06
FPD	1 (3.03)	15.12±0.00	24.39±0.00	23.15±0.00	8.03±0.00
Modified bone height					
High bone group	20 (60.60)	19.74±3.60	29.66±4.43	31.18±3.79	11.44±2.34
Low bone group	13 (39.40)	18.42±3.97	29.49±4.19	30.77±3.70	12.35±3.63
Modified bone width					
Wide bone group	19 (57.58)	18.59±4.10	29.97±4.06	30.73±4.12	12.14±3.23
Narrow bone group	14 (42.42)	20.09±3.15	29.13±4.65	31.42±3.16	11.33±2.40

Pearson's correlation coefficient demonstrated that there was a significant positive correlation between the PCAS and the PCA in Test 3 ($p < 0.05$, r = .382), however, there were no significant positive correlations between the PCAS and the PCA in Test 1 and 2 or between the percentage change of the PCAS and the percentage change of the PCA ($p > 0.05$).

Discussion

The present study enrolled 39 patients from the Prosthodontic Department, Faculty of Dentistry, Chulalongkorn University, who were treated with MDI retained L-CDs. Due to the period of our study, 6 patients were excluded: 4 patients delayed to participate in the surgical and prosthetics procedure and 2 patients lost their dentures after the surgical procedure. However, these 6 patients eventually received MDI retained L-CD treatment. Therefore, 33 patients fully participated throughout the masticatory efficiency evaluations in our study.

Elderly patients typically present with medically compromised conditions and are often anxious about the perceived risks and complications of conventional implant surgery. Indeed, elderly patients commonly reject standard size implant retained overdenture treatment (Ellis, et al., 2011). The minimally invasive MDIs can be an alternative treatment for these patients. 32 of 33 subjects (96.97%) in our study had the age above 60 years old with 12 healthy subjects (36.36%) classified as ASA classification I, and 21 subjects (63.64%) classified as ASA classification II with at least one systemic disease; hypertension, hyperlipidemia, diabetes mellitus, heart disease, osteoarthritis, liver disease, anemia or Systemic Lupus Erythematosus (SLE). Our results demonstrated that all of the elderly and medically compromised subjects in the present study could receive MDI retained L-CD treatment with 100% clinical success in the 3 month follow-up period and the MDI treatment improved their L-CD function with favorable osseointegration outcomes. However, long-term follow-up is recommended.

Our study evaluated the masticatory efficiency before and after MDI retained L-CD treatment subjectively and objectively. The subjective method is easy to perform, low cost, and not time consuming. Moreover, patient-based measurements of satisfaction in the chewing ability of their denture are important in assessing dental treatment success (Hsu, et al., 2012). Use of the food intake questionnaire is recommended because it is simple and accurate in evaluating chewing ability (Leake, 1990). Many studies used a food intake questionnaire, varying the number and types of foods according to the different cultures of the subjects. In Thailand, the self-reported questionnaire for subjective evaluation using a 4-point rating scale was developed in a previous study to evaluate the chewing ability of implant retained L-CDs in an elderly population (Kunon and Kaewplung, 2014). The 14 food types in this questionnaire were selected from common Thai foods, which are typically consumed by the elderly individuals living in the central region of Thailand as well as those in our study. Thus, this food intake questionnaire was appropriate for the subjective evaluation of the masticatory efficiency of our subjects.

The objective masticatory evaluation method in the present study used the two-colored wax cube analysis as utilized in previous studies (Prapatrungsri, et al., 2010; Liangbunyaphan et al., 2011; Liangbunyaphan et al., 2012; Chokpreecha and Kaewplung, 2013; Kunon and Kaewplung, 2014). This objective method provides reliable quantitative results without emotional impact from the subjects (Slagter, et al., 1992). The wax cube analysis method does not require complicated manufacturing and needs only a few minutes to perform the test without discomfort to the subjects. The analysis of the chewed wax is uncomplicated and the subjects could visually understand the result of

the assessment. Moreover, the reliability test for the Image J Program analysis presented high reliability at an Alpha value of .999.

Our study also investigated the variables affecting masticatory efficiency before and after treatment with the MDI retained L-CDs. We found that the age and sex of the subjects did not affect the masticatory efficiency. These findings support the results of previous studies (Millwood and Health, 2000; Kunon and Kaewplung, 2014). Moreover, the results showed that the type of upper prosthesis did not affect chewing ability. This may be because the subjects had opposing pairs of posterior teeth. Although the dentures of the subjects had different cusp angulations, a previous study found that there was no significant difference in masticatory efficiency between 30, 20, and 0 degree artificial teeth or between porcelain and acrylic resin teeth (Nasr, et al., 1967). This indicates that treatment with MDIs can improve the masticatory efficiency in L-CD patients irrespective of the type of upper prosthesis.

The present study also focused on the edentulous ridge height and width of the mandible, finding that the different bone groups showed increased scores between the 3 tests. There was no significant difference in the mean value of the evaluation scores between the high and low bone groups or between the wide and narrow bone groups. Thus, the bone height and width of the residual mandible did not have an impact either subjectively or objectively on masticatory efficiency in our study. The patients with high or low bone or with wide or narrow bone had improved masticatory efficiency of their L-CD after MDI treatment.

The MDIs used in the present study enabled the 14 severe bone resorption subjects (42.42%) who had ridge widths less than 5 mm and were classified in the Narrow bone group to receive MDI retained L-CD treatment without any additional surgical procedures such as bone grafting or ridge augmentation. Although standard size implant placement requires adequate bone width, augmentation procedures can be used to solve this issue. However, these techniques are complex and can cause post-operative pain and discomfort for the patient as well as incurring additional costs and treatment time. MDIs can be used in many cases to avoid the limitations in patients with severely resorbed mandibles.

The treatment using MDI retained L-CDs in our study not only improved denture stability and masticatory efficiency, but also improved patient satisfaction and overall outcomes. This minimal invasive intervention is appropriate in patients who may not be candidates for conventional surgical procedures of the standard size implant placement or ridge augmentation procedures. These patients may benefit from the flapless insertion technique and immediate loading of the denture on the MDIs. In our study, almost of the subjects were elderly with a maximum age of 83 years old and most patients had at least one systemic disease. The minimum bone width of the subjects was found to be only 3.37 mm. These cases received MDI treatment with favorable clinical outcomes demonstrating that MDI treatment can help in achieving an increased Oral health related Quality of life (OHRQoL), which is in agreement with a previous study (de Souza, et al., 2015). Moreover, the relatively inexpensive MDIs enables the dentist to offer this treatment option to more patients. The cost of the 4 MDIs treatment in this study was approximately 10,000 baht/300 US$, however, that of the 2 standard size implant treatment was approximately 20,000 baht/600 US$. The survival rate of the MDIs for definitive prosthodontic treatment should be investigated in a long-term study to confirm the treatment success of MDI retained overdentures.

Conclusion

In our study, the patients with conventional L-CDs showed significant improvement in their masticatory efficiency after treatment with the MDI retained L-CDs by both subjective and objective evaluation. The age, sex, general health status, type of upper prosthesis, mandibular bone height, and width had no influence on the improvement of the masticatory efficiency after MDI placement. Our study suggests that treatment with MDI retained L-CDs can be an alternative treatment in the elderly patients to improve their denture stability and masticatory efficiency with favorable outcomes. However, long-term observation is recommended.

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References

Ahn MR, An KA, Choi JH, Sohn DS. Immediate loading with mini dental implants in the fully edentulous mandible. Implant Dent. 2004;13:367-72.

Bidra AS, Almas K. Mini implants for definitive prosthodontic treatment: a systematic review. J Prosthet Dent. 2013;109:156-64.

Chokpreecha N, Kaewplung O. A comparison of masticatory efficiency using the wax cube analysis method before and after implant-retained lower complete denture insertion. Master's Thesis, Department of prosthodontics. Faculty of dentistry, Chulalongkorn University, Thailand. 2013.

Christensen GJ. The 'mini'-implant has arrived. J Am Dent Assoc. 2006;137:387-90.

de Souza RF, Ribeiro AB, Della Vecchia MP, Costa L, Cunha TR, Reis AC, et al. Mini vs. Standard Implants for Mandibular Overdentures: A Randomized Trial. J Dent Res. 2015;94:1376-84.

Ellis JS, Levine A, Bedos C, Mojon P, Rosberger Z, Feine J, et al. Refusal of implant supported mandibular overdentures by elderly patients. Gerodontology. 2011;28:62-8.

Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, Gizani S, et al. The McGill consensus statement on overdentures. Mandibular two implant overdentures as first choice standard of care for edentulous patients. Gerodon. 2002;19:3-4.

Flanagan D, Mascolo A. The mini dental implant in fixed and removable prosthetics: a review. J Oral Implantol. 2011;37:123-32.

Griffitts TM, Collins CP, Collins PC. Mini dental implants: an adjunct for retention, stability, and comfort for the edentulous patient. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2005;100:81-4.

Hsu KJ, Lee HE, Lan SJ, Huang ST, Chen CM, Yen YY. Evaluation of self-assessed screening test for masticatory ability of Taiwanese older adults. Gerodontology. 2012;29:1113-20.

Kunon N, Kaewplung O. Comparison of chewing ability of mandibular implant-retained overdenture patients using the subjective and the objective assessment. CU Dent J. 2014;37:171-82.

Leake JL. An index of chewing ability. J Public Health Dent. 1990;50:262-7.

Liangbunyaphan S, Chaiteerapapkul P, Kaewplung O. A comparative study of chewing efficiency using 3 evaluation methods. J Dent Assoc Thai. 2011;61:176-82.

Liangbunyaphan S, Chaiteerapapkul P, Kaewplung O. The development of wax cubes hardness for chewing ability evaluation. J Dent Assoc Thai. 2012;62:85-92.

McGarry TJ, Nimmo A, Skiba JF, Ahlstrom RH, Smith CR, Koumjian JH. Classification system for complete edentulism. J Prosthod. 1999;8:27-39.

Millwood J, Heath MR. Food choice by older people: the use of semi-structured interview with open and closed questions. Gerodontology. 2000;17:25-32.

Misch CE. Density of bone: effect on treatment plans, surgical approach, healing and progressive bone loading. Int J Oral Implantol. 1990;6:23-31.

Morneburg TR, Proschel PA. Success rates of microimplants in edentulous patients with residual ridge résorption. J Oral Maxillofac Implants. 2008;23:270-6.

Nasr MF, George WA, Travaglini EA, Scott RH. The relative efficiency of different types of posterior teeth. J Pros Dent. 1967;18:3-11.

Prapatrungsri K, Petsom A, Kaewplung O. The evaluation of chewing ability by locally developed wax cubes. J Dent Assoc Thai. 2010; 60:66-73.

Preoteasa E, Meleşcanu-Imre M, Preoteasa CT, Marin M, Lerner H. Aspects of oralmorphology as decision factors in mini-implant supported overdenture. Rom J Morphol Embryol. 2010;51: 309-14.

Shatkin TE, Shatkin S, Oppenheimer A. Mini dental implants for the general dentist. Compend Contin Educ Dent. 2003;24:26-34.

Shatkin TE, Shatkin S, Oppenheimer BD, Oppenheimer AJ. Mini dental implants for long-term fixed and removable prosthetics: a retrospective analysis of 2514 implants placed over a five-year period. Compend Contin Educ Dent. 2007;28:92-9.

Slagter AP, Olthoff LW, Bosman F, Steen WH. Masticatory ability, denture quality, and oral conditions in edentulous subjects. J Prosthet Dent. 1992;68:299-307.

Takata Y, Ansai T, Awano S, Fukuhara M, Sonoki K, Wakisaka M, et al. Chewing ability and quality of life in an 80-year-old population. J Oral Rehabil. 2006;33:330-4.

Tallgren A. The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years. J Prosthet Dent. 1972;27:120-32.

United States Food and Drug Administration. Pre-market notification; Indication for use statement of mini dental implants. http://www.accessdata.fda.gov/cdrh_docs/pdf3/K031106.pdf. Published 2003. Accessed February 16, 2013.