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ORIGINAL ARTICLE

Use of a single implant to retain mandibular overdenture: A preliminary clinical trial of 13 cases

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KEYWORDS

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within-subject
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Abstract *Background/purpose:* Given that many patients find the cost of mandibular rehabilitation through complete overdenture implants to be beyond their financial scope, many seek a more affordable treatment. The aims of this study were to compare the clinical outcomes of single mandibular implant-retained overdentures versus that of complete dentures.

Materials and methods: Thirteen edentulous patients with a mean age of 71 years were enrolled in this investigation. They were treated with a single implant inserted into the mandibular midline, followed by rehabilitation with complete dentures. The mandibular dentures were adhered with a locator or magnetic attachment after 10 weeks of adaptation. Patient satisfaction was assessed by means of a visual analogue scale (VAS) questionnaire both on the day of attachment connection and 3 months later. Chewing efficiency was assessed by a sieve test before and after connecting the attachment. Within-subject comparisons were performed either by using paired-sample *t*-tests or Wilcoxon signed-rank tests to test patient satisfaction and chewing efficiency ($P = 0.05$).

Results: No implants were lost nor were denture fracture found during the observation period. Significant improvements were observed in all parameters of patient satisfaction (with *P* values ranging from <0.001 to ~ 0.043) after attachment of the mandibular dentures with a single midline implant. Furthermore, the objective chewing efficiency of patients significantly improved after implant connection ($P < 0.001$).

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Conclusion: Within the limitations of this preliminary prospective clinical study, single-implant-supported mandibular overdentures were a successful alternative treatment option for elderly edentulous patients.

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Introduction

Rehabilitation using complete dentures on edentulous patients who suffer from a compromised alveolar bone often results in denture soreness, poor retention and instability unclear pronunciation, and low chewing efficiency. Implant-retained overdentures are widely applied for the rehabilitation of edentulous jaws as it is able to increase retention rates of prosthesis, enhance the masticatory function and reduce the absorption of alveolar bone by regulating neuromuscular adaptation.^{1,2}

Compared to the conventional complete denture, two or more implant-retained mandibular overdentures can promote function and enhance success rates.^{3–5} The York consensus statement recommends at least two implants to support a mandibular overdenture for edentulous patients.⁶ However, economic constraints—especially among the emerging elderly population in developing countries—make this treatment strategy financially challenging.^{7,8} In order to reduce the cost and time of treatment, the concept of single implant-retained overdenture provides another option for elderly populations.

In previous studies and practice, using a single implant in the mandibular midline area with ball or locator attachments to support overdenture produced favourable outcomes.^{9,10} An *in vitro* model study demonstrated that the single implant-supported overdenture increased retention and stability as compared with the conventional complete overdenture; furthermore, the biomechanical effects were comparable to those observed in a mandibular two-implant retained overdenture.¹¹ In comparison with two-implant overdenture, the single implant presented other advantages such as lower component costs and shorter treatment time while maintaining comparable patient satisfaction.¹²

Although single implant-retained overdentures are a promising alternative for compromised edentulous patients, the limited research dedicated to this treatment concept has restricted its acceptance and implementation. In this present study, we carried out a clinical investigation using within-subject comparison in order to evaluate the treatment outcomes of single implant-retained overdenture with regards to patient satisfaction and chewing efficiency.

Materials and methods

Thirteen patients, three men and 10 women, between 53 and 83 years of age (mean age: 71 years) who had been completely edentulous for at least 2 years were included in this study. All participating in the treatment plan signed an informed consent form, and ethical approval was granted by

the Ethics Committee of the Wuhan University, Wuhan, Hubei, People's Republic of China. Treatment criteria specified that patients had been completely edentulous for at least 12 months with maladaptive full dentures; additionally, patients had to have sufficient mandibular bone volume for implant geometries as minimal as 4 mm in diameter and 10 mm in length as well as being medically suitable for implantation. Moreover, smokers were encouraged to stop smoking in order to lessen differentiating factors.

All patients had a normal range of mandibular motion with no deviation and presented no obvious mucosa lesions nor pathological changes in either maxilla or mandible. These were all confirmed and documented before surgery by means of panoramic, conventional lateral cephalometric radiographs, and radiographic evaluation of the proposed implant placement site.

All patients were given a single implant longer than 10 mm in length; the implant was placed in the mandibular midline. Thirteen ITI SLA implants (Straumann Standard Implant. Institut Straumann AG. CH-4002 Basel. Switzerland), with lengths of 10 mm or 12 mm and a diameter of 4.1 mm, were inserted according to each patient's individual bone height as suggested in the manufacturer's recommended protocol. Two weeks after implant placement, a new set of complete maxillary and mandibular dentures were created. The patients were allowed to use the new complete dentures for about 10 weeks to ensure proper adaptation.

After assessing the implant osseointegration by means of periapical film and intro-oral examination, two types of attachments were used. In the case of magnetic attachment ($n = 6$, Magfit-IP, Cushion Type, Aichi Steel Corporation, Japan), a keeper was connected and tightened to 30 NCm with a torque wrench, ensuring 2 mm of height above the mucosa. The magnetic part was attached precisely to the keeper. Self-curing acrylic resin was applied to affix the two parts. The counterpart in the denture was ground down to create the necessary space, and an overflow hole was drilled. Resin was applied to the space created by the grinding, and then the patient was asked to keep the dentures in centric occlusion using moderate pressure. After full polymerization of the resin, the dentures were removed (Fig. 1 A–E). Alternatively, a locator attachment ($n = 7$, Zest Anchors, Inc. Escondido, CA, USA) was used in some cases. The abutment was located on the implant and tightened to 30NCm with a torque wrench, ensuring 2 mm of height above the mucosa. A blue locator male was employed to connect the implant and the overdenture (Fig. 2 A–B).

To assess patients' degree of satisfaction, each patient completed self-administered questionnaires that followed the visual analogue scales (VAS) method. These surveys were taken on the day of attachment placement (before

the placement and implant connection), and three months after that, respectively. Each VAS questionnaire consisted of a 100 mm horizontal line, with the beginning and the end stating opposing responses of "not at all satisfied" and "totally satisfied." Each patient was asked to draw a vertical line cross the line segment to show his or her current degree of satisfaction with the overdenture. The scores were recorded by measuring the length from the left starting point to the vertical response line. The content of the questionnaires included: 1) Comfort level: 0 = strong foreign body sensation, multiple oral sore spots; 100 = without foreign body sensation, without hindering tongue or other muscle movements, without pain; 2) Speech: 0 = unclear pronunciation; 100 = without hindering clear pronunciation; 3) Retention and stability: 0 = denture dislodgement during speech or chewing movement; 100 = without denture dislodgement during speech or chewing movement; 4) Chewing ability: 0 = only

fit for chewing soft food; 100 = without hindering chewing ability at all; 5) General satisfaction: 0 = not at all satisfied; 100 = totally satisfied. We processed the patients' answers and formulated a comprehensive evaluation of these stated factors.

Chewing efficiency was evaluated by way of a sieving test immediately before and after the attachment placement. The sieve with apertures of 2.4 mm was used for food sieving. Dried peanuts were weighed and separated into sealed containers with 2.0 g in each. Each patient was instructed to masticate 2.0 g peanuts for 30 seconds. The particles were removed, sieved and weighed three times. After being dried in a 60°C oven for 6 hours, the particles were weighed. Chewing efficiency was calculated: $\text{chewing efficiency} = (\text{total weight} - \text{residual weight}) / \text{total weight} \times 100\%$.

In the instance that the data gathered through VAS scores and chewing efficiency had Gaussian distributions

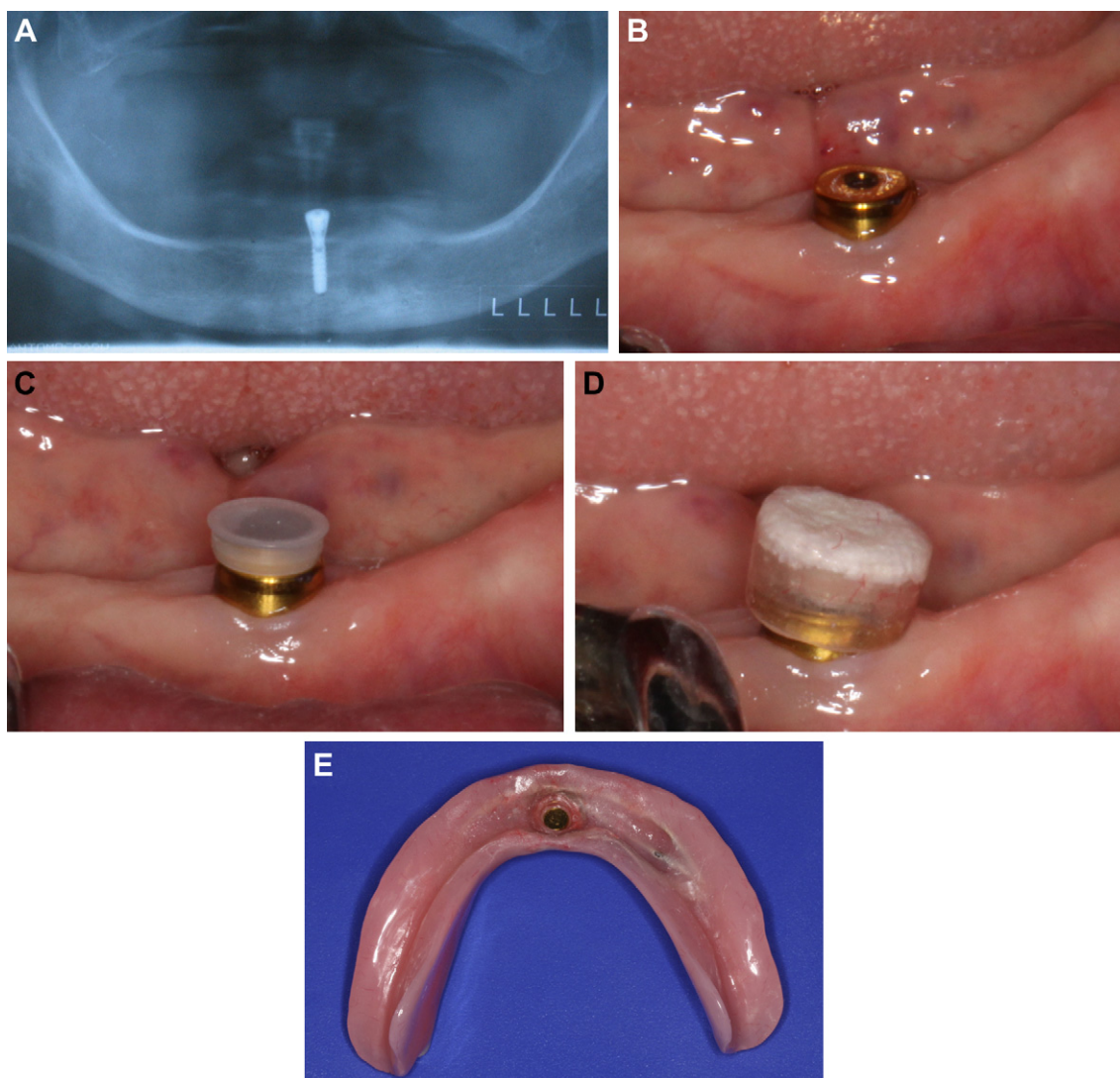


Figure 1 Placement of magnetic attachment after placing implant. (A) Frontal panoramic radiograph view of a symphyseal single implant; (B) occlusal view: fixing the keeper on the implant; (C) occlusal view: accurate match of the keeper and the magnet; (D) occlusal view: fixing the keeper and the magnet with self-curing acrylic resin; (E) basal view of overdenture with magnetic attachment.

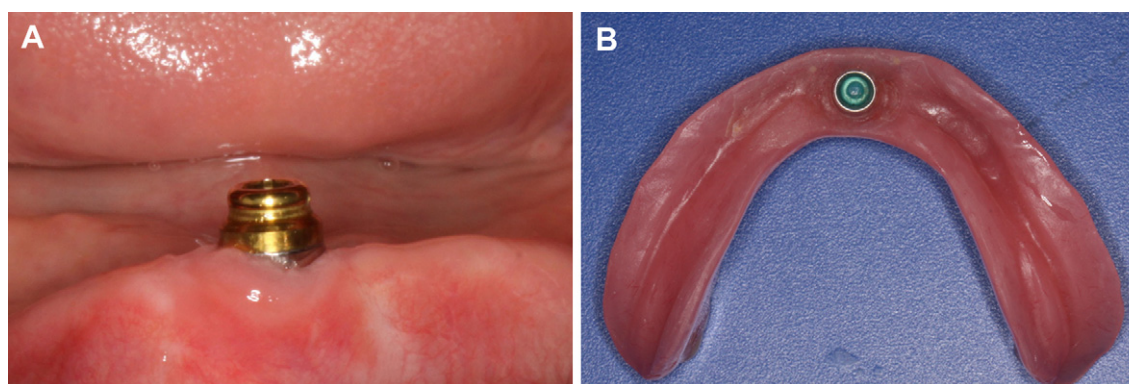


Figure 2 Placement of locator attachment after placing implant. (A) Occlusal view: fixing the locator abutment on the implant. (B) Basal view: blue locator male in the overdenture.

and standard deviations, the data and results of complete dentures and single implant-supported overdentures were compared with a paired t-test. If the results did not present Gaussian distributions, a Wilcoxon signed rank test was adopted instead (SPSS Inc., Chicago, IL, USA). The significance level was set at 0.05.

Results

Thirteen patients were enrolled in this investigation. During the 3 months of observation period, no implants were lost nor did fractures occur.

The results of the VAS analysis are shown in Table 1. The patients gave single implant-retained overdenture a significantly higher score of general satisfaction than that attributed to complete denture ($P = 0.043$). The patients' satisfaction with regards to retention and stability with single implant-retained was remarkable ($P = 0.001$), and the single implant-retained overdenture was reported to improve both speech ($P = 0.021$) and chewing ability ($P = 0.007$) significantly. The scores of comfort levels with the single implant-supported overdenture were significantly higher than those reported for the complete denture. Any sore spots mentioned by patients with a compromised alveolar bone were no longer an issue after placing the attachment.

The chewing efficiency was evaluated using sieving test. As shown in Table 2, in accordance with the chewing ability

scores detailed in the VAS, the single implant-retained overdenture achieved a significantly higher chewing efficiency than conventional complete denture ($P = 0.001$).

Discussion

It has been widely accepted that two-implants-supported mandibular overdentures should be recommended for edentulous patients, although single-implant-supported overdentures also show practical and clinical potential. This study is the first study using within-subject comparison to investigate the treatment outcomes of single implant-retained overdenture. The evaluations conducted before and after placing the attachments referenced the same denture in order to exclude many interference factors.

Previous case reports provided favourable results using this single implant technique.^{13,14} Comparable implant outcomes and patient satisfaction have also been reported using one or two implants to support a mandibular overdenture.^{12,15} In comparison with conventional mandibular overdenture, the single implant-retained overdenture achieved significantly higher VAS scores in comfort level, retention and stability, speech, chewing ability and general satisfaction. The sustained sore spots caused by complete denture disappeared in most cases after placing the implant. Chewing efficiency is an important index for measuring masticatory function, as it indicates comprehensive oral function as well as the effectiveness of

Table 1 Comparison of VAS scores between mandibular complete denture and single implant-retained overdenture.

VAS scores	Before implant connection (<i>n</i> = 13)		After implant connection (<i>n</i> = 13)		t/Z	P
	Mean ± SD	Median (Range)	Mean ± SD	Median (Range)		
Comfort level	81.9 ± 15.0	90.00 (54–100)	89.6 ± 10.1	91.00 (65–99)	2.260 ^a	0.043
Speech	90.4 ± 4.7	90.00 (80–100)	93.7 ± 5.0	94.00 (80–99)	2.662 ^a	0.021
Chewing ability	78.1 ± 14.1	80.00 (57–92)	91.2 ± 6.2	93.00 (80–99)	3.250 ^a	0.007
Stability and retention	72.2 ± 20.1	70.00 (20–94)	91.9 ± 9.8	96.00 (72–100)	−3.182 ^b	0.001
General satisfaction	85.5 ± 13.6	92.00 (50–98)	92.9 ± 15.7	95.00 (80–99)	2.856 ^a	0.014

VAS: Visual analogue scale.

Value of significance: $P < 0.05$.

^a Paired t-test.

^b Wilcoxon signed rank test.

Table 2 Comparison of chewing efficiency between mandibular complete denture and single implant-retained overdenture.

	Before implant connection (n = 13)	After implant connection (n = 13)	t	P
	Mean ± SD	Mean ± SD		
Chewing efficiency	*50.4 ± 21.6	*64.4 ± 13.3	4.367	0.001

Value of significance: $P < 0.05$.

Paired t-test.

* Data were presented as percentage of peanuts passing through the sieve.

the prosthesis. With the single implant-retained overdentures, the patients' chewing efficiency was significantly enhanced, indicating the improvement of retention and stability of the overdenture, and an increase in the amplitude and velocity of chewing movement. Furthermore, in this study locator and magnetic attachment significantly improved patient satisfaction as well as chewing efficiency when compared with the described outcomes of conventional denture, thus providing favourable clinical outcomes for this alternative treatment plan.

The implants were placed in the anterior area of mandible. This region is the preferred site in single implant-retained overdenture for the following reasons: thicker cortical bone, lowered surgery risk by avoiding the inferior alveolar nerve and blood vessels, and, finally, a larger tissue-supporting area to prevent overloading on implant. Although there was some concern regarding the potential risk of mandibular fracture because of the anatomical structure,¹³ there was little difference found between the risk anticipated in overdentures retained by one implant and those retained by two implants.¹⁶

In addition to valuable physical results, maintenance cost is an important factor for selecting the type of implant attachment component. Locator and ball attachment have been reported to achieve favourable outcomes.^{13,17,18} Ball attachment is often employed in single implants because its elastic retainer allows for the slight rotation of the overdenture and passes the load to surrounding bone tissue. Although ball attachment suits the requirement of implant mucosa-supported overdenture by balancing the axial load and preventing perio-implant bone tissue damage, the high maintenance cost of this attachment type has limited its application.¹⁹ In this study, locator attachment was employed because the nylon retention cap can be easily replaced at a relatively low cost if needed.

As for other types of attachment, magnetic attachment presents its own advantages. For example, it can reduce occlusal vertical dimension. Moreover, the lateral stress can be greatly diminished as a result of small horizontal attractive forces, thus promising a better long-term prognosis. The structure of magnetic attachment also makes it easier for the patient to put on the prosthesis. However, with magnetic attachment, if the keeper and magnet are not attached accurately, the flux leakages will reduce

retentive force.^{20,21} In order to avoid this type of incident, self-curing acrylic resin was applied to hold the two components together to ensure accurate attachment. This procedure greatly enhanced retention. It should be noted that the retentive force provided by magnetic attachment is more stable than that produced by locator attachment, but it is also lower. For this reason, the maintenance cost of magnetic attachment is lower than other types of attachments.^{7,22} Favourable outcomes have been reported in studies using magnetic attachment in two-implants-retained overdenture,^{23,24} but the study of applying magnetic attachment in single implant-retained overdenture is rare. In the present study we used this type of attachment treatment on three patients. The promising results suggested single implant-retained overdenture with magnetic attachment may be an option worth considering in the rehabilitation of edentulous patients.

In summary, the single implant-retained mandibular overdenture with locator and magnet attachment achieved better patient satisfaction and promoted chewing efficiency than those reported with conventional mandibular dentures. Compared with the more commonly used two implant-retained overdenture, the lower component costs and reduced treatment time with comparable satisfaction make single implant-retained mandibular overdenture a promising alternative—particularly for patients with an atrophic mandible, severe systemic diseases, or financial difficulties. While further long-term follow-up is needed before the single implant-retained mandibular overdenture is recommended for general application, it does look to be a beneficial and valuable alternative treatment.

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