Original article

Patient preferences for different tooth replacement strategies for the edentulous mandible: A willingness-to-pay analysis

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Abstract

Purpose: The aim of this study was to evaluate patients' economic preferences for two different tooth replacement strategies for the edentulous mandible namely conventional complete dentures (CCDs) and implant overdentures supported by two implants (IODs), using a willingness-to-pay (WTP) analysis.

Methods: Twenty-six elderly patients who had been rehabilitated with either a mandibular CCD or IOD were invited to participate in this study. All participants were provided with the details of the two treatment protocols, including advantages, disadvantages, and treatment costs. The patients were then asked to indicate their maximum WTP values for each protocol using a payment card method for contingency evaluation.

Results: Fifteen patients with mandibular CCD (CCD-Group) and 12 patients with IOD (IOD-Group) participated in the study. Overall, the median and maximum WTP values recorded for IOD therapy were significantly higher than those for CCD therapy ($p < 0.05$). Both treatment groups recorded maximum WTP values for CCD therapy, which exceeded the market cost (¥30,000 [US\$280]), CCD-Group: ¥50,000 (interquartile range [IQR]: 40,000 – 65,000), and IOD-Group: ¥45,000 (IQR: 30,000–85,000). However, both groups registered a median and maximum WTP values for IOD therapy lower than the market cost (¥780,000 [US\$7,300]), CCD-Group: ¥500,000 [IQR: 300,000 – 750,000], IOD-Group: ¥700,000 [IQR: 500,000–800,000]).

Conclusion: The maximum WTP values recorded for IOD therapy were significantly higher than CCD therapy in both treatment groups. While patients were willing to pay more than the current market costs for CCDs, they were not willing to meet the market value for IODs.

Keywords: Willingness-to-pay, Economic preference, Preference-based healthcare, Complete denture, 2-implant overdenture

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1. Introduction

Two-implant overdentures (IODs) are globally recognized as the gold standard treatment option for rehabilitation of the edentulous mandible [1,2]. Numerous randomized control trials have demonstrated that IODs can improve masticatory function [3], patient-reported clinical outcomes [4], and oral health-related quality of life [5,6], compared to conventional complete dentures (CCDs).

However, in order to make decisions that maximize patients' well-being, clinicians need to understand how patients value the potential treatment options as well as the clinical outcomes. Positive treatment outcomes are achieved not only through positive clinical outcomes but also by the impact on patients' lifestyle and psychological well-being [7]. The need for surgery, long treatment durations, more frequent dental visits, and

increased costs associated with IOD makes it inconvenient for patients. In comparison, CCD therapy is less invasive, less time-consuming, and less expensive. In particular, considering that the majority of patients undergoing edentulous rehabilitation are the elderly, these factors can impact their decision-making.

As such, assessing patient preferences is now acknowledged as an essential element of patient-centered healthcare [8] since it encompasses all aspects of healthcare interventions on patients' well-being [7,9].

One approach to determining patient preference is to determine a monetary valuation through the individual's expression of their maximum "willingness-to-pay" (WTP) [10]. WTP is a form of contingency valuation that can be used to assign monetary values to healthcare interventions and outcomes. Participants are presented with information about the healthcare interventions to be valued and are asked to indicate the maximum amount that they would be willing to pay [11,12]. Where financial costs are borne by patients, it is important to take into account their financial preferences in addition to the actual delivery costs.

There is currently only one report in literature assessing patients' WTP for IOD treatment among edentulous patients, of a Canadian population [13]. However, WTP for CCDs was not assessed, and the authors did not compare patients' preferences between CCDs and IODs. Furthermore, this report was limited to a small number of countries.

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In Japan, the out-of-pocket cost for IOD therapy is currently approximately 100 times more expensive than CCD therapy. The standard treatment cost of one CCD is set at ¥30,000 (US\$280) under a universal health insurance scheme. The co-payment of insured patients ranges from 10 to 30% depending on their age and income level, and thus the actual payment is between ¥3,000 and ¥9,000. In comparison, patients must pay the full market costs of IOD treatment with no price controls imposed as part of the universal health insurance scheme. The current market price of IOD treatment in Japan ranges from ¥700,000 to ¥800,000 (US\$6,500–7,500), including consultation, oral assessment, imaging, oral surgery, and prosthodontic procedures. No previous studies have assessed whether this market cost corresponds to patients' monetary valuation of prosthodontic rehabilitation in Japan.

Therefore, this study aimed to evaluate the preferences of elderly edentulous Japanese patients for different tooth replacement strategies (CCDs and IODs) for the edentulous mandible using a WTP analysis. The secondary aim is to compare the maximum WTP values recorded by patients who have never used an IOD (CCD group) and patients who currently use an IOD (IOD group).

2. Materials and Methods

2.1. Sampling Methods

Patients aged 60 years and older, who had previously undergone oral rehabilitation using CCDs or IODs, were invited to participate in the study. All participants were provided with oral and written information about the study and filled written consent forms as part of the recruitment process. The study received full ethical approval from the Faculty of Dentistry Ethics Committee, Tokyo Medical and Dental University (TMDU), Tokyo, Japan (D2015-511).

Participants in the IOD group were recruited from a pool of patients who completed a previous research study with members of the research team in TMDU [4]. As part of the previous study, each patient voluntarily agreed to receive mandibular IODs with two implants and magnetic attachments. All the patients had used CCDs prior to the provision of IODs, and most of the participants in this study experienced improvements in their clinical satisfaction with IODs. For example, the median scores for the Oral Health Impact Profile for edentulous patients (OHIP-EDENT-J) [14] improved from 25 to 16.5 ($p=0.062$) over four years. As part of the previous study, patients received financially subsidized treatment i.e. each participant paid ¥520,000 for implant placement, but additional costs for prosthodontic rehabilitation were waived.

Patients within the CCD group were recruited from a pool of patients who had received CCDs provided by specialized clinical staff in the Prosthodontic Department at TMDU Dental Hospital. Participants were matched to the IOD group in terms of age profile and sex distribution.

The inclusion criteria for the study included: (a) edentulous mandible rehabilitated with CCD or IOD, (b) attending TMDU Dental Hospital for review, and (c) aged over 60 years. The exclusion criteria included (a) presence of xerostomia, (b) temporomandibular arthrosis, (c) oral dyskinesia, and (d) lack of verbal communication.

2.2. Data Collection

All data were collected by a researcher (ST) who was blinded to the patient treatment groups and was not involved in the previous IOD study. Patients were interviewed and data collected including age, sex, employment status, income level, oral health-related quality of life using the Japanese version of OHIP-EDENT-J, and patient satisfaction using a validated questionnaire (Patient's Denture Assessment; PDA) [15].

As part of the interview, all participants were provided with a detailed description of the treatment protocols for oral rehabilitation using both CCDs and IODs. The description included clinical treatment stages, expected outcomes, timelines, and costs involved. The information was provided as verbal and written forms with further illustrations using clinical photographs (Table 1). The patients were informed that the treatment costs for a CCD were ¥30,000 (US\$280) and ¥780,000 (US\$7,300) for an IOD.

These figures were generated from information available from the Japanese universal healthcare insurance scheme for CCDs and from an average of prices charged by practitioners in TMDU for IOD treatment. Participants were encouraged to ask questions to understand the treatment protocols. The participants were then asked "Suppose that you will receive CCD/IOD, what is the maximum amount of price that you are willing to pay for each option?" They indicated their maximum WTP values for each treatment using the payment card method for contingency valuation (Table 1). If their WTP was beyond the range of the default price options, they were asked to provide an exact value.

2.3. Statistical Analysis

The collected data were analyzed using PASW Statistics 18 software (formerly SPSS; IBM Company, Tokyo, Japan). Mann Whitney U tests and chi-square tests were used to examine differences in demographic characteristics between the two treatment groups. Mann-Whitney U tests were also used to compare differences in maximum WTP values between the two treatment groups. WTP values were treated as continuous variables in this analysis. The Wilcoxon signed-rank test was used to compare differences in maximum WTP values for CD and IOD therapies within each group. Spearman's rank correlation test was used to assess the correlation of WTP values with demographic factors, clinical satisfaction, and clinical experience. $P < 0.05$ was set as the level of statistical significance for all analyses.

3. Results

A total of 26 patients were recruited for the study with 15 participants ($n=15$) in the CCD group and 11 participants ($n=11$) in the IOD group. The characteristics of the patients in both groups are shown in Table 2. Although the median age of the patients in the CCD group was higher (77.0 years) than in the IOD group (70.0 years), there were no statistically significant differences between the two groups when analyzed for age ($p=0.413$) and sex ($p=0.851$). While 80% ($n=12/15$) of the CCD group were not employed, 50% ($n=5/10$) of the IOD were employed or self-employed. However, there was no significant difference in employment status between the two groups ($p=0.115$). Analysis of OHIP-EDENT-J scores did not reveal any statistically significant differences between the CCD and IOD groups ($p=1.000$) nor did PDA summary scores ($p=0.180$).

With regard to household income level, the majority of the participants in both the CCD and IOD group reported that the current yearly household income was below ¥5,000,000 (Table 3). The distribution of the current yearly household income were similar between the CCD and IOD groups. However, there were some differences in the recorded previous highest income levels. While 83% ($n=9/11$) of the IOD group reported that their highest household income level was more than ¥6,500,000, only 57% ($n=8/14$) of the CCD group were above ¥6,600,000, with the remainder between ¥3,000,000 and ¥5,000,000. The average yearly household income of elderly Japanese (> 65 years old) was ¥3,186,000 in 2018 [16].

The maximum WTP values recorded for the two treatments for both the CCD and IOD groups is shown in Table 4. The majority of patients in both the CCD and IOD groups reported significantly higher maximum WTP values for IOD treatment than CCDs ($p<0.05$). The median and maximum WTP values for CCD treatment recorded by the CCD group were ¥50,000 (IQR: 40,000 – 65,000) and ¥40,000 (IQR: 30,000–100,000) for the IOD group. Both groups reported the median and maximum WTP values for CCDs, which were higher than the stated market costs (¥30,000) (Figure 1). In total, 73% ($n=11/15$) of the CCD group and 54% ($n=6/11$) of the IOD group recorded maximum WTP values that were above the market price (Figure 1). Conversely, neither of the groups were willing to meet the market cost of ¥780,000 [CCD-Group: ¥500,000 (IQR: 300,000–750,000), IOD-Group: ¥700,000 (IQR: 500,000–800,000)] (Figure 2). Only 26% ($n=4/15$) of the CCD group and 36% ($n=4/11$) of the IOD group were willing to pay more than the market price (Figure 2).

Further analysis examined correlation coefficients between maximum WTP values and age, sex, employment status, current income level, highest previous income level, OHIP-EDENT-J score, PDA summary score,

Table 1. Summary of the two treatment strategies.

	Conventional Complete Denture (CCD)	Two-implant Overdenture (IOD)
Oral Photo
Denture Stability	As CCD cannot be fixed, the denture stability which influences oral function is poorer than IOD.	As IOD can be fixed, the denture stability which influences oral function is better than CCD.
Treatment Flow	1. Primary impression 2. Final impression 3. Jaw relations 4. Wax try-in 5. Denture delivery 6. Denture adjustment × 5	1. Primary impression 2. Final impression 3. Jaw relations 4. Wax try-in 5. Denture delivery 6. Denture adjustment × 5 7. CT scan 8. Implant surgery 9. Denture adjustment × 4 (3 months for Healing) 10. Delivery of attachment 11. Denture adjustment × 3
Total Treatment Period	4 months	10 months
Dental Visit Frequency	10 times	20 times
Surgical Invasion	× (non-invasive)	○ (implant surgery)
Healing period	N/A	3 months
Attachment	×	○
Treatment Cost (¥)	30,000	780,000
Insurance Coverage	○ High income group at any age: 70% Others aged 70-75yr: 80% Others aged 75 +: 90%	×
WTP (¥)	1. Under 10,000 (How much?) 2. 10,000 3. 20,000 4. 30,000 5. 40,000 6. 50,000 7. 60,000 8. 70,000 9. 80,000 10. 90,000 11. Over 10,000 (How much?)	1. Under 100,000 (How much?) 2. 100,000 3. 200,000 4. 300,000 5. 400,000 6. 500,000 7. 600,000 8. 700,000 9. 800,000 10. Over 1,000,000 (How much?)

Table 2. Baseline demographics of the CCD and IOD groups.

	CCD-Group (n=15)	IOD-Group (n=11)	P-value ¹
Age	77.0 (IQR: 73.5 – 79.5)	70.0 (IQR: 63.0 – 82.0)	0.413
Gender	Male (n=9; 60%) Female (n=6; 40%)	Male (n=7; 64%) Female (n=4; 36%)	0.851
Employment Status	Employed (n= 3; 20%) Unemployed (n= 12; 80%)	Employed (n= 5; 50%) Unemployed (n= 5; 50%)	0.115
OHIP-EDENT-J ² (summary score)	14.5 (IQR: 9.0 – 23.0)	16.0 (IQR: 10.0 – 20.0)	1.000
PDA ³ (summary score)	87.6 (IQR: 80.5 – 93.6)	91.3 (IQR: 88.2 – 95.6)	0.180

1. Mann Whitney U tests and chi square tests were used to examine differences of demographic characteristics between the two treatment groups. 2. OHIP-EDENT-J: The Japanese version of the Oral Health Impact Profile for edentulous. The summary score ranging from 0–76 was indicated in this table and lower score means better oral health related quality of life. 3. PDA: Patient's Denture Assessment. The summary score ranges from 0 (completely dissatisfied) to 100 (completely satisfied).

Table 3. Distribution of the different yearly income levels.

Yearly Income Level ¹ (¥)	Current		Past (Highest)	
	CCD group [n (%)]	IOD group [n (%)]	CCD group [n (%)]	IOD group [n (%)]
under 3,000,000	2 (14%)	3 (27%)	0 (0%)	0 (0%)
3,000,000 – 3,500,000	3 (21%)	2 (18%)	1 (7%)	0 (0%)
3,500,000 – 4,000,000	2 (14%)	2 (18%)	1 (7%)	0 (0%)
4,000,000 – 4,500,000	1 (7%)	0 (0%)	1 (7%)	1 (9%)
4,500,000 – 5,000,000	2 (14%)	2 (18%)	2 (14%)	0 (0%)
5,000,000 – 5,500,000	1 (0%)	0 (0%)	0 (0%)	0 (0%)
5,500,000 – 6,000,000	0 (0%)	0 (0%)	0 (0%)	1 (9%)
6,000,000 – 6,500,000	0 (0%)	1 (9%)	1 (7%)	0 (0%)
6,500,000 – 7,000,000	1 (7%)	0 (0%)	0 (0%)	2 (18%)
over 7,000,000	2 (14%)	1 (9%)	8 (57%)	7 (64%)

1. The average yearly household income of Japanese older adults (> 65 years old) was ¥3,186,000, and that of other generation (<65 years old) was ¥6,635,000.

and previous clinical experience (CCD vs. IOD). This analysis did not determine whether any of these factors were significantly correlated with the maximum reported WTP values for this patient sample (Table 5).

4. Discussion

This study is the first to examine economic preferences for both CCDs and two-implant IOD treatment strategies among a group of elderly edentulous Japanese patients. This study demonstrates that while elderly Japanese patients clearly value IODs, they were not willing to meet the

Table 4. Willingness to pay (WTP) for each treatment strategy.

Treatment strategy	Market Cost (¥)	Median WTP (¥)		<i>P</i> -value ¹
		CCD-Group	IOD-Group	
CCD	30,000	50,000 (IQR: 40,000 – 65,000)	40,000 (IQR: 30,000 – 100,000)	0.507
IOD	780,000	500,000 (IQR: 300,000 – 750,000)	700,000 (IQR: 500,000 – 800,000)	0.148
		<i>P</i> -value ² : 0.001	<i>P</i> -value ² : 0.003	

1. Mann-Whitney U test was used to compare differences in WTP values between the two treatment groups. 2. Wilcoxon signed-rank test was used to compare difference in WTP values for CCD and IOD therapy within each group.

Fig. 1. Distribution of WTP values for conventional complete denture (CCD) treatment. The broken line indicates the market price for CCDs treatment [¥30,000 (=US\$280)]. **Fig. 2.** Distribution of WTP values for two-implant overdenture (IOD) treatment. The broken line indicates the market price for IODs treatment [¥780,000 (=US\$7,300)].

market value for this treatment. In comparison, this group of patients recorded maximum WTP values for CCDs, which were significantly in excess compared to the market costs presented. Despite considerable clinical evidence regarding the benefits of IODs over CCDs for the edentulous elderly, patient preferences may not exactly correspond. Traditionally, clinicians measure the relative merits of different healthcare strategies based on clinical outcomes alone [17]. However, professionals should consider that the patient's well-being is not always defined by clinical outcomes [7, 18].

The patients in this study did indicate that they were willing to pay more for IODs than for CCDs. Similar findings have been observed in a Canadian population of elderly edentulous patients. In that study, almost half of the participants wearing CCDs and the majority of those wearing IOD were willing to pay significantly more for IOD therapy than CCDs. However, the same Canadian study also found that only around 50% of

patients with IODs and a significant minority of patients wearing CCDs were willing to pay the market price for IODs [13]. Other studies from Ireland and Hong Kong [12, 19] have also demonstrated that many elderly patients are not willing to pay the market price for dental implant treatment for missing teeth, albeit in partially dentate populations. These results suggest that many elderly patients may view dental implants as simply too expensive or may be unwilling to proceed with a more lengthy and complex treatment plan, which includes surgery. Previous studies have demonstrated that many elderly patients are unwilling to proceed with the surgical phase of dental implant treatment despite high success rates in this age group [20].

Data from the OHIP-EDENT-J and the summary scores from the PDA illustrate that the CCD group in this study was reasonably satisfied with their CCDs. Actually, the satisfaction scores generated were not significantly different from those of the IOD group. This has been

Table 5. Correlations of WTP values with demographic factors and clinical satisfaction.

	WTP for CCD	WTP for IOD
Age	0.331 ($p=0.099$)	0.194 ($p=0.343$)
Gender (1: Male, 2: Female)	0.342 ($p=0.087$)	0.016 ($p=0.938$)
Employment Status (1: Employed, 2: Unemployed)	-0.129 ($p=0.539$)	0.152 ($p=0.469$)
Current Income	-0.111 ($p=0.598$)	0.127 ($p=0.544$)
Highest Income	-0.003 ($p=0.988$)	0.283 ($p=0.171$)
OHIP-EDENT-J ²	-0.023 ($p=0.912$)	-0.231 ($p=0.268$)
PDA ³	0.034 ($p=0.868$)	0.219 ($p=0.283$)
Clinical Experience (1: CCDs, 2: IODs)	-0.144 ($p=0.482$)	0.296 ($p=0.142$)

Spearman's rank correlation coefficients were indicated in this table.

demonstrated in a number of studies including those using a qualitative methodology [20] where one patient described their CCD as “...the most comfortable dentures I have ever had... they're fantastic, they are brilliant. And as for eating, I eat anything I want and it does not affect us...I can manage it no problem at all with these dentures.” In this study, all the CCDs were constructed by specialized prosthodontic staff within the Dental School of TMDU. This suggests that well-constructed CCDs can still be used successfully to rehabilitate some edentulous elderly patients. Given the fact that the patients in the CCD group were generally satisfied with their existing prostheses, it is difficult to understand why many of them would be willing to spend significantly larger sums of money on IODs. Although the median maximum WTP values for IOD treatment were not significantly different between the two groups ($p=0.148$), the CCD group was likely to value IOD treatment at a lower level than the IOD group, as shown in Figure 2.

Previous data from the IOD group illustrated that they experienced improvements in both Oral Health-related Quality of Life Scores (OHIP-EDENT-J) and Denture Satisfaction scores (PDA) when they transitioned from CCDs to IODs. The median scores for OHIP-EDENT-J and PDA among the IOD group improved from 25 to 16.5 ($p=0.062$), and from 67.5 to 90.0 ($p=0.004$), respectively. Despite this, it is interesting to note that many of them were not willing to pay the market cost of IODs. However, it should be noted that these patients had previously paid for part of their treatment at a cost of ¥520,000. While the median maximum WTP value recorded for this group was ¥700,000, this was higher than the previous subsidized costs that they had paid. This was also significantly higher than the maximum WTP values expressed by the CCD group who had no experience with IODs. Nevertheless, there is no doubt that IODs remain an expensive treatment option for elderly edentulous patients. In most countries, while CCDs may be provided as part of state-funded care, IODs are rarely covered by such schemes.

Previous studies have demonstrated that socioeconomic factors, including educational attainment [21, 23] and income levels [12, 22, 23], were positively associated with maximum WTP values within healthcare. Factors such as income levels would appear to make sense in terms of WTP values, as observed in daily economic activity. However, in this study, there were no significant correlations detected between WTP values and factors such as age, sex, employment status, income level, and previous clinical experience. Given the complex interplay of a number of these factors, this would suggest the need for a qualitative approach to gain further insight into patient preferences for treatment, including the role of finance in decision-making and valuation.

While this novel study provides important results for dental professionals and policy-makers, a number of limitations must be acknowledged. First, the sample size was small. In Japan, the number of elderly edentulous patients is relatively small because of changes in the oral epidemiology of the general population. Recruitment of the patients in this study was

challenging, with the numbers limited by the proportion of patients with IODs available from a previous study. Further recruitment of elderly edentulous patients with CCDs was not carried out, as this would have undermined the work undertaken to create a closely matched cohort with the IOD patient group. As the IOD patients were recruited from a previous study, there is always potential for bias in the results generated. Patients in the IOD group had experience with both treatment options, but those in the CCD group did not. The level of alveolar bone resorption might have also affected the patients' WTP, but this was not measured across both treatment groups in the study. Blinding of the researcher conducting the interviews was instituted in an attempt to reduce potential bias. As the patients in the IOD group had paid subsidized costs for their treatment, this may also have biased the WTP values that they recorded. Given the relatively small number of study participants, it is difficult to argue that this is a representative sample of the general population. Further studies with larger numbers of participants carried out in different environments would be required to confirm external validity. Furthermore, collection of before and after WTP values could demonstrate how clinical interventions impact patients' preferences over time.

5. Conclusion

Among this elderly edentulous population, the maximum WTP values recorded for IOD treatment were significantly higher than CCD treatment. However, the majority of patients with experience of both CCDs and IODs indicated maximum WTP values in excess of current market cost of CCDs. In contrast, the patients were not willing to pay the market costs for IOD treatment, including those who had been previously successfully rehabilitated using this approach.

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