

## Functional Restoration with Implant Overdentures - Discussion on Desired Denture Border Configuration

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### Introduction

Prosthetic treatment modalities of edentulous patients will include ① Conventional complete dentures, ② Fixed prostheses with dental implants (Fixed bone anchored bridges), and ③ Removable type of Implant retained overdentures (hereafter IOD).

Especially among them above, since “The McGill Consensus Statement on Overdentures”<sup>1)</sup> (will be detailed later) was published in 2002, attention has been attracted to IOD in international clinical scenes.

In this study, viewing of future possible acceptance of IOD in Japan, issues about it will be organized and a clinical case will be presented where a complete denture was transitioned to IOD. And the findings from them will be discussed by relating with views of denture border configuration.

### Why Implant Overdentures now?

#### 1. Acceptance of implant overdentures in different countries

The table shows national surveys of IOD conducted in ten various countries in 2001.<sup>2)</sup>

When viewed the percentage of mandibular edentulous patients to all implant treated patients (boxed red in the table), 81% of edentulous mandibles in the Netherlands was available for implant therapy, while only 7% was known in Japan, and majority of implant choices were applied for partially

edentulous cases.

Percentage of fixed implant-supported prostheses and IOD are investigated over implant treatments of edentulous mandibles. (Fig.1) 93.2% of mandibular edentulous implant cases were performed with IOD in the Netherlands. On the other hand, in Sweden, 88.1% of cases indicated to fixed implant-supported prostheses.

Reason for popular implantation in the edentulous mandibles in Europe when compared with Asian patients is that specific European country permits health-care insurance coverage for implant therapy, and that there are overwhelmingly larger numbers of edentulous patients than in Japan and others.

For example in the Netherlands, population of edentulous patients is more common than other nations, and IOD on edentulous mandible is covered by the health-care insurance, while fixed implant supported prostheses are excluded from the system. Thereby results are extraordinary share of IOD cases than other nations.

Meanwhile in Sweden, fixed implant supported prostheses are paid by the health-care insurance whereas IOD is not paid. Consequently number of fixed implant supported prostheses is larger than that of IOD. In Greece, too, implant superstructures are covered by the insurance and so choices of implant prostheses are more than other nations.

**Table 1** Clinics in Each Country, Response Rate, No. of Implant Overdentures (IODs) and Fixed Implant-Supported Protheses (FISPs), and Mean % of Implant Patients with Edentulous Mandibles

Country	No. of responding clinics	Response rate (%)	No. of IODs (Q1)	No. of FISPs (Q2)	% of implant patients with edentulous mandibles (Q3)
Canada	1	100	60	65	30
Finland	36	80	197	439	39
Greece	34	85	148	943	26
Japan	17	100	25	41	7
Korea	5	83	21	22	17
Netherlands	27	63	3,778	276	81
Norway	16	67	42	80	19
Singapore	16	59	18	15	17
Sweden	28	93	87	647	18
United Kingdom	233	53	778	448	25

Q1 to Q3 = question No. from the questionnaires.

**Table**

The table shows national surveys of IOD conducted in ten various countries in 2001. <sup>2)</sup>

As stated above, acceptance is varied depending on different type of cost-sharing that is available to patients.

Now here in Japan what is the reason for small proportion of implants in edentulous mandibles? The literature above suggested higher expenses of implantation and less number of edentulous patients in the range of fifties and sixties of age groups in contrast to other nations.

In addition, the author thinks that awareness of IOD is not well known to dentists and consequently the information is not well conveyed to their patients as an alternative way of treatment modality. And so IOD will be used more in the future accordingly along with spread of information in Japan.

**2. Increase of difficult clinical case and aging society**

In Japan, thanks to health conscious awareness throughout the nation, number of remaining teeth of elderly population is increasing year after year.<sup>3)</sup> As a result, we practitioners know as much about the fact of decreased ratio of edentulous patients in clinical scenes.

But in the meantime, among edentulous patients, we feel more cases exhibiting severe resorption of alveolar crests. This might mean that dentists do not have to extract teeth without careful consideration as periodontal care is getting more popular. Also patients prefer not to have unwanted tooth

extraction even if periodontal disease is far advanced.

In case of severe ridge reduction, it tends to be more difficult to have retention and stability of complete denture. Even if extensive bone anchored bridge is planned with multiple implant support, it often limits less number of implants due to lack of bone volume. Like in this difficult clinical case, IOD is known very effective.

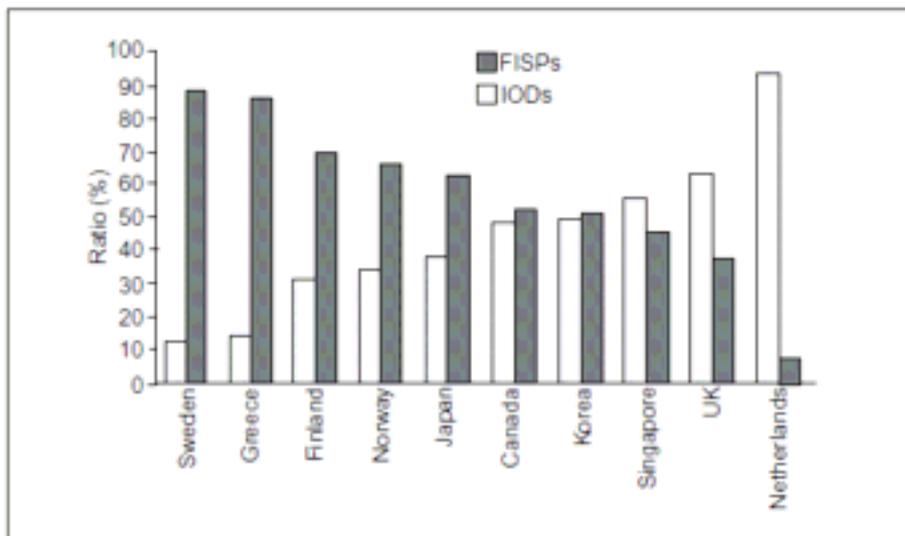
Furthermore as number of aged patients increase, there are patients, among them, who demand specific protheses with higher degree of function. In other words some portion of complete denture wearers is increasing in the hope of a denture with “better mastication and less mobility”.

IOD has the merit of less surgical invasion that is beneficial to aged patients. At the same time, IOD is able to enhance denture function so that it could offer powerful option of treating.

IOD will be appreciated high internationally and will be coming in to our practice. Protheses by IOD will be demanded more definitely thanks to less surgical invasion, less burden of economy and high cost-benefit performance. We should be ready as soonest for organizing necessary knowledge of IOD and keep our patients well informed.

**Evidence up to now of implant retained overdentures**

**1. Edentulous patient implant therapy**  
Prosthetic treatment with fixed type



**Fig 1** Ratio of implant overdentures and fixed implant-supported prostheses provided to patients with edentulous mandibles in 10 countries in 2001. The countries are arranged according to increasing ratios of implant overdentures. *FISP* = fixed implant-supported prosthesis; *IOD* = implant overdenture.

**Fig.1**

Ratio of Bone anchored bridge and IOD provided to edentulous mandibles in 10 countries<sup>2)</sup>

bone anchored bridge by placing an implant in an edentulous arch is well established as regimen of therapy. As to long term postoperative results, evaluation over 20 years of observation has been reported. (Survival rate of 98.9%)<sup>4)</sup> IOD, however, is promising to edentulous patients because implant problems are involved with the magnitude of surgical invasion and financial demands.

Schmitt and Zarb reviewed in 1998 about IOD and concluded that there is a need in it for less invasive and less expensive for the maladaptive edentulous patient and that it is an equally effective treatment option as the bone anchored bridge.<sup>5)</sup>

## 2. Comparison of complete dentures and implant retained overdentures

According to the report results of Kapur et al., edentulous patients were grouped in wearing complete dentures and IOD wearers respectively in order to survey in cross-sectional study. And satisfactory responses of IOD group were significantly enhanced in mastication and comfort, and general satisfaction was also established.<sup>6)</sup>

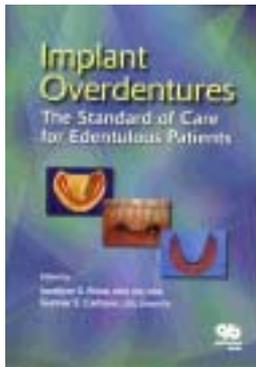
And Bakke et al. placed two implants between mental foramen in the patients who had worn complete dentures for more than five years in order to change into IOD, and as a result, bite force exerted more efficiently to permit more segmented hard and tough food, reporting that chewing activity increased. And every patient felt improved function and reduction of chewing pain.<sup>7)</sup>

## 3. The McGill Consensus Statement: 2002

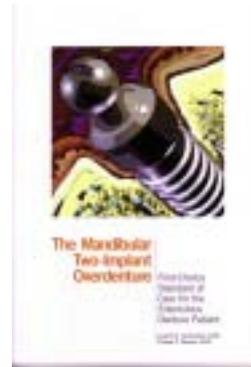
While evidences for IOD were being fixed, a consensus statement was presented in somewhat sensational manner from McGill University Canada in 2002.<sup>1)</sup>

The statement is titled, "Mandibular two-implant overdentures as first choice standard for edentulous patients". In other words, it means that conventional type of complete denture is not always most optimal choice of prosthetic treatment for edentulous patients. (Fig.2) This idea has shaken the entire world for a good opportunity to make IOD popular.

Also in recent years, Carpentieri and Tarnow have published a book titled



**Fig.2** Textbook of IOD published based on the McGill Consensus Statement



**Fig.3** Textbook of Two-Implant Overdenture by Carpentieri and Tarnow

“The Mandibular Two-Implant Overdenture: First-choice of Care for the Edentulous Denture Patient” (Fig.3)

#### 4. Fixed type or removable? Consensus report of AO '06

A consensus report on choices whether fixed type or removable be provided to implant dentures for edentulous patients was presented in Academy of Osseointegration Meeting as in the followings.<sup>8)</sup>

##### Object:

“Does the type of implant prosthesis affect outcomes for the completely edentulous arch?”

In order to respond to this question, overall systematic review was conducted including a meta-analysis.

##### Material:

Relevant numbers of literature were searched on PubMed website, and 3,189 articles were assessed by reviewers to extract 72 papers finally.

##### Result:

Implant survival rates in the maxilla and mandible of edentulous subjects (average rate) are shown in Fig.4 and 5.

##### Conclusion:

- ①Maxillary and mandibular bone anchored bridge as well as IOD in the mandible have high average survival rates for over 5 to 10 years.
- ②There was no significant difference of implant survival rate in the mandible between the fixed type and IOD.
- ③In the maxilla, evidences for comparing the fixed type and IOD were insufficient. (Although two reports

published before 2006 as well as three reports published later than 2006 were studied, the findings were similar.)

Conclusions drawn from AO consensus report suggested that there are existing extraordinary supporting evidences for IOD in the edentulous mandibles. Bryant et al. had already noted low success rate of IOD in the maxilla<sup>9)</sup>, and AO had reported same.

IOD in the maxilla, however, should be noted that preoperative bone volume by definition is already insufficient. In case IOD selection is decided rather not a bone anchored bridge on the ground that the jaw bone is reduced and that quality is poor, IOD is already at risk from the very beginning.

#### 5. Implant retained overdentures that are friendly to elderly patients

Meijer et al. reports on the success rate of IOD when performed on groups of younger adults and aged patients.<sup>10)</sup> When a 3 year prospective study was compared between younger patients (mean age of 46 years) and elders (mean age of 68 years) with IOD in edentulous mandibles, there were no significant differences in Plaque Index, Gingival Index, Bleeding Index, and Probing Depth. And there were no statistical differences of bone loss among young adults (1.2mm) and elderly (0.8mm), either. In this article they discussed that IOD should be an effectively safe treatment measure equally for elderly patients as well as for disease patients.



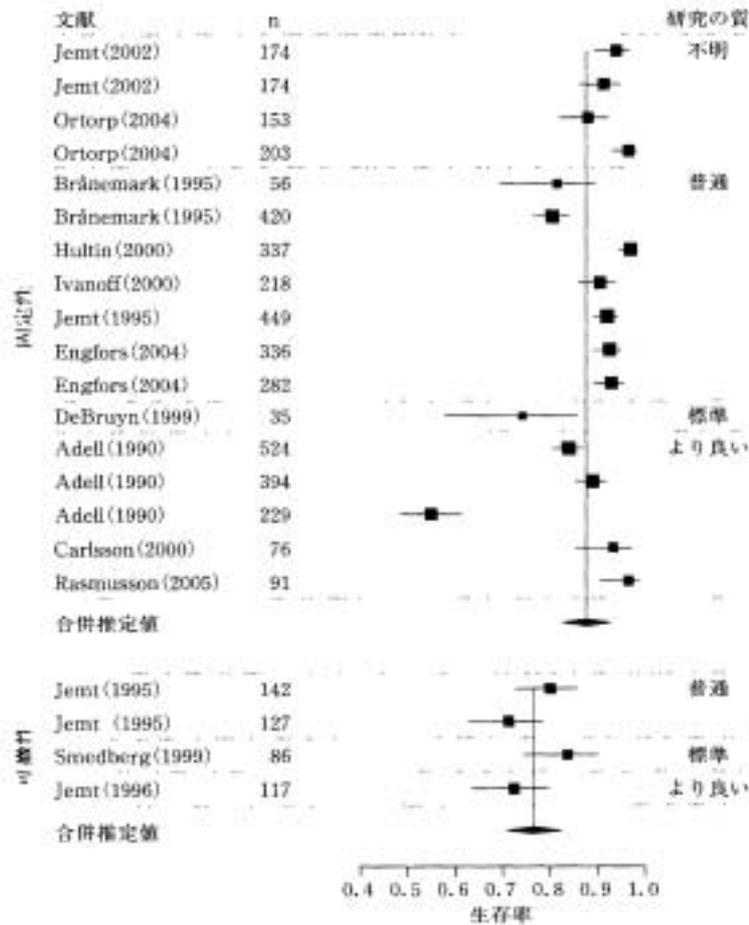


Fig.5 Implant survival rate in the edentulous maxilla (average rate)<sup>8)</sup>

Maxillary removable prosthesis, in general, is an overdenture with maximum number of 4~6 implants connected with bar attachment that resists rotation.

As stated above, elderly patients have progressively advanced ridge reduction, and so implant retained prostheses there should not only reconstruct the tooth structure but also the resorbed alveolar crest. For this reason IOD is more excellent to improve oral function and esthetics than the fixed type of bone anchored bridge.

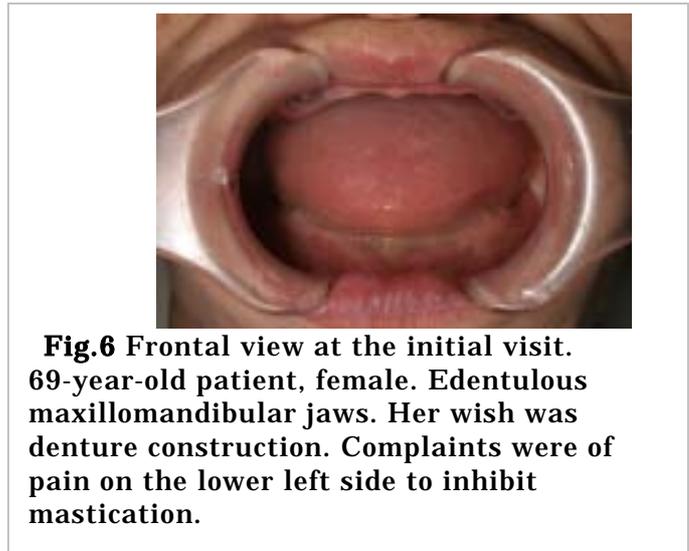
### **Clinical effects of implant retained overdentures**

As previously stated, in most scientific articles so far published, functional restoration of edentulous patients with IOD have been assessed mainly from patient's satisfaction index. Therefore the author valued clinical effectiveness of IOD in view of bite force and occlusal power zone, or occlusal center of gravity, in a case where a complete denture was redesigned to transition to IOD.

The patient was at age of 69 female, and her lower complete denture showed suction effective to some degree, but she desired further improvement of efficiency. She also complained that she could not bite in pain on the left lower jaw.

#### **1. Examination and Diagnosis**

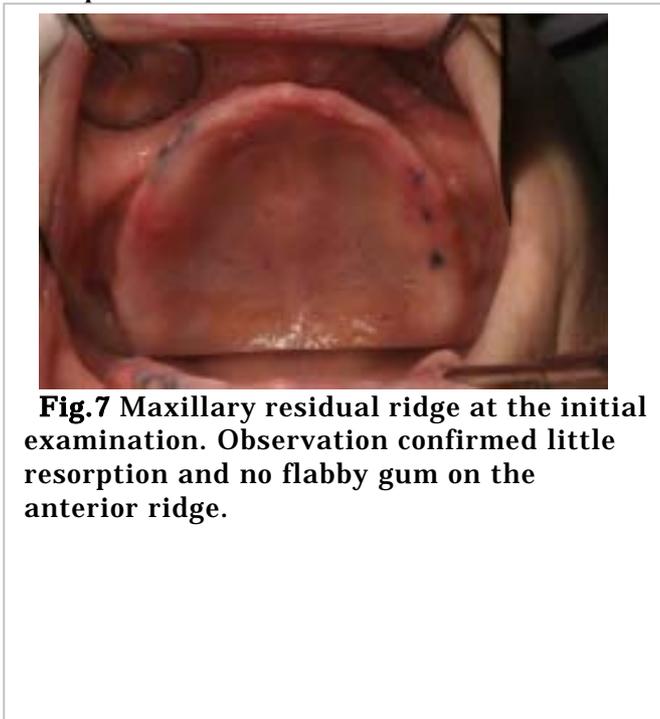
At her initial visit, the alveolar ridges of maxilla and mandible were examined, (Fig.6 ~ 8) and the mandible ridge was reduced and the alveolar mucosa was almost mobile except its crest area. Especially the ridge on the left side, a painful side, was precisely observed, and the alveolar crest was discontinued and not well defined. The alveolar crest from the anterior part and the crest running from the retromolar pad did not meet but passed each other.



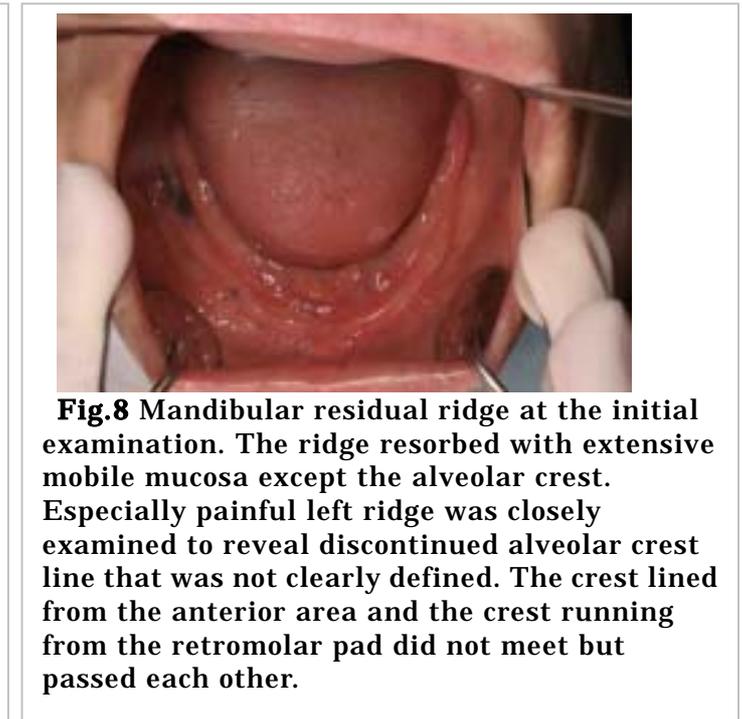
**Fig.6** Frontal view at the initial visit. 69-year-old patient, female. Edentulous maxillomandibular jaws. Her wish was denture construction. Complaints were of pain on the lower left side to inhibit mastication.

The panoramic radiograph (Fig.9) reveals the posterior alveolar bone is almost resorbed to the mandibular canal area, but no abnormality is confirmed on the temporomandibular joint configuration.

The patient seemed rarely adapted with the dentures and had requested frequent remaking apparently in the past. The dentures that she worn at the initial visit (Fig.10) were used with metallic bladed teeth and exhibited stable tapping. Also the mandibular denture was additionally retained by suction effect, and it made a sound when the denture was dislodged. But the patient was not satisfied with them.



**Fig.7** Maxillary residual ridge at the initial examination. Observation confirmed little resorption and no flabby gum on the anterior ridge.



**Fig.8** Mandibular residual ridge at the initial examination. The ridge resorbed with extensive mobile mucosa except the alveolar crest. Especially painful left ridge was closely examined to reveal discontinued alveolar crest line that was not clearly defined. The crest lined from the anterior area and the crest running from the retromolar pad did not meet but passed each other.



**Fig.9** The panoramic radiograph at the initial visit reveals the alveolar bone in the posterior region almost reduces to the mandibular canal, but no abnormality is confirmed on the temporomandibular joint.



**Fig.10** The upper and lower dentures that she worn at the initial visit. Metallic bladed teeth were used and tapping was tested stable. The mandibular denture was additionally retained by suction effect, and it made a sound when the denture was dislodged. But the patient was not satisfied with them.



**Fig.11, 12** Patient's facial appearances demonstrated a little low posture in vertical intermaxillary distance on wearing dentures, and she was not content with present esthetics.

Patient's facial appearance (**Fig.11, 12**) demonstrated a little low posture in vertical intermaxillary distance while wearing dentures, and she was not content with present appearances.

In order to fulfill her wish of further improvement of efficiency, IOD was designed. When tomographic images were examined to determine bone volume at the implant site (**Fig.13, 14**), bone width and height became decreased in the mandible.

## 2. Treatment plan

A complete denture was planned for the maxilla, and for the mandible a two-implant IOD was at first planned. But the residual ridge width and bone volume were limited and the patient preferred minimally invasive surgery, and so four units of narrow type implants were placed and ball type attachments were used for retaining the prosthesis.

## 3. Treatment process

Four units of MDI Mini Dental Implant (diameter 1.8mm x 10mm) were placed. (**Fig.15**)



**Fig.13, 14** Tomographic mandible bone images. In order to fulfill her wish of further improvement of efficiency, IOD was designed. For examining bone volume of implant placement site, tomographic radiography was taken. In the anterior mandible the ridge bone height was known as only about 15mm.



**Fig.15** 4 units of MDI Mini Dental Implant (diameter 1.8mm x 10mm) were placed.

IOD is expected to have better mastication in comparison with a complete denture. An appropriate denture border shape will have to be altered in accordance with this feature. For that purpose, as a denture impression taking technique, a functional impression method based on patient-driven process would be desired rather than the muscle trimming impression method driven by an operator using an impression compound. With that idea in mind, Biofunctional

Prosthetic System (Ivoclar Vivadent) as a functional impression method was taken in this case. (Fig.16 ~ 26)



**Fig.16** BPS impression process was used for constructing IOD. Study models were set up with Centric Tray and mounted on an articulator (Stratos 300).



**Fig.17** Wax rims assembled with UTS Adapter



**Fig.18** Functional impression of maxilla. Using the wax rims shown in Fig.17, patient was allowed for functional movements for impression taking.



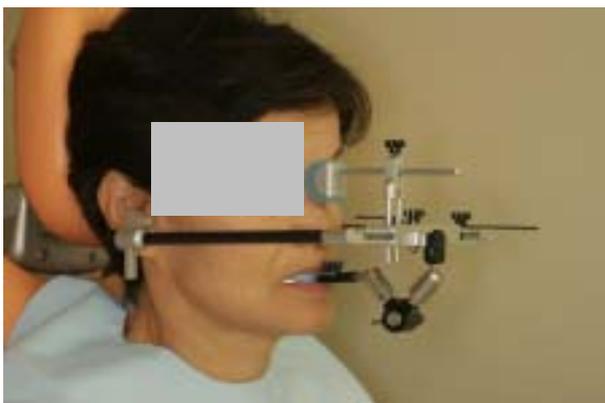
**Fig.19** Mandibular functional impression was taken at closed mouth position.



**Fig.20** Gothic arch tracing with Gnathometer "M". Apex and tapping point were coincided.



**Fig.21** Vertical intermaxillary distance and horizontal mandibular position were measured at the same time of impression taking.



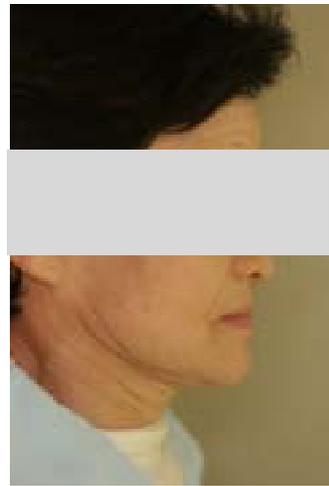
**Fig.22** Facebow transfer with UTS Transferbow



**Fig.23, 24** Finished maxillary complete denture and IOD in the mandible.



**Fig.25** IOD in the mouth.



**Fig.26** Facial appearance with IOD seated in the mouth.

#### **4. Assessment of effectiveness of treatment**

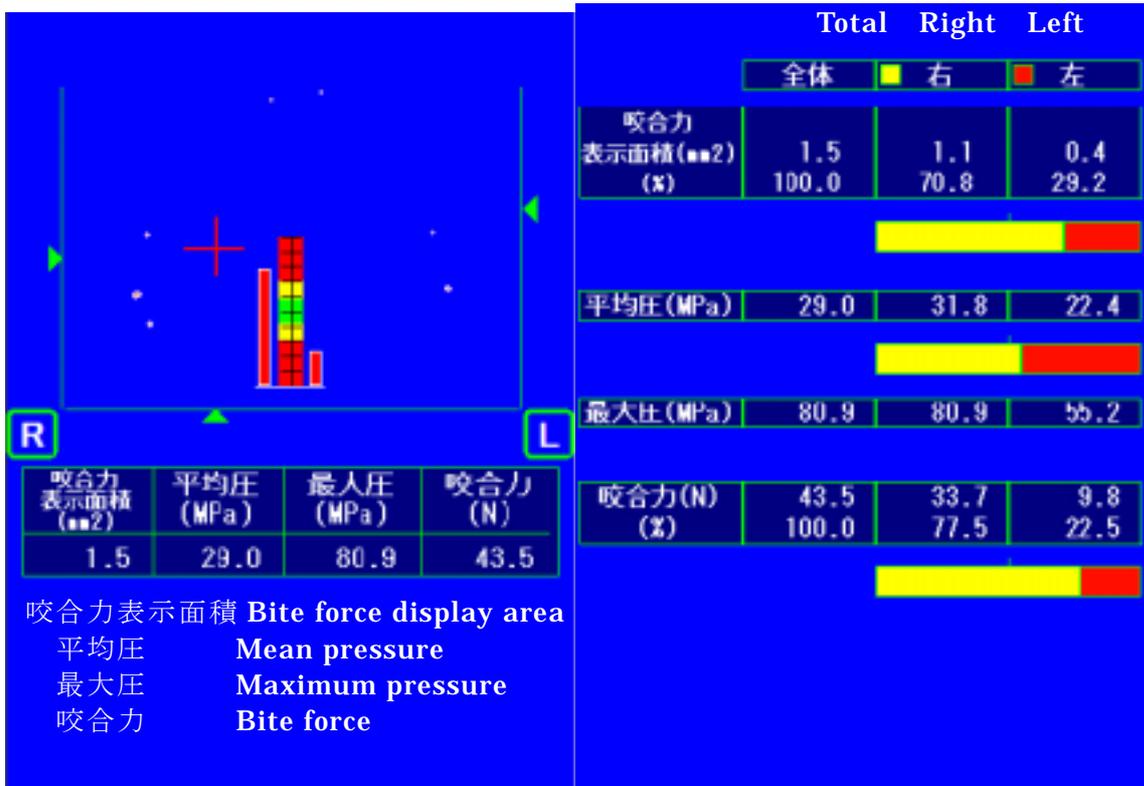
Improvement of masticatory function by the implant placement was assessed with "Dental Prescale". Detective devices were Dental Prescale 50H, R-type (GC Co.) and a bite force detector, Occluser FPD-709 (GC).

Detected bite force of dentate healthy adults (average age of 22.7) is reportedly  $915.29 \pm 391.43\text{N}$  for males and  $824.80 \pm 342.92\text{N}$  for females.<sup>13)</sup> And even aged individuals who have achieved 8020 Movement are reported to have shown strong bite force no less than young adults of 20's of normal occlusion.<sup>14)</sup>

In this clinical case, her preoperative bite force showed 43.5N, about 1/20 weaker than normal healthy dentate mouth, and it showed only 9.8N on her painful left side, where she hardly masticated food. Accordingly occlusal power zone, or occlusal center of gravity (marked in +) showed deviated to the right side. (Fig.27, 28).

After one week of wearing IOD (Fig.29, 30), the bite force showed 76.2N, a little improved than pretreatment.

Again after two weeks of wearing (Fig.31, 32), the force was 87.7N, and after one month (Fig.33, 34), it increased to 144.5N, exhibiting equal biting on both sides. And the gravity center came to rest in the middle.



**Fig.27, 28** Pretreatment (wearing of complete denture) bite force and occlusal power zone, or occlusal center of gravity. Total bite force (43.5N) is low and especially the painful left side is low (9.8N). So occlusal power zone, or occlusal center of gravity (marked in +) deviate to the right side accordingly.



**Fig.29, 30** After one week of wearing IOD



Fig.31, 32 After two weeks of wearing IOD



Fig.33, 34 After one month of wearing IOD, bite force (144.5N) increased 3 times more than pretreatment, and occlusal power zone or gravity center is stabilized in the middle.

● **Features of border configuration of complete denture and partial denture (Fig.35~37)**



**Fig.35** Border configuration of complete denture (developed with fit checking material). Function of border is mainly marginal sealing and it tends to become thicker flange.



**Fig.36** Border configuration of partial denture with multiple tooth loss (developed with same). With less remaining teeth, border sealing from base will help stabilize the base.



**Fig.37** Border configuration of partial denture with small number of tooth loss (developed with same). Due to minimum function of border sealing, it tends to become thinner flange.

## 5. Discussion

Masticatory efficiency is said to be significantly correlated with occlusal surface area.<sup>15)</sup> As the area increases, bite force will increase to make occlusion stable accordingly.<sup>16)</sup>

In this clinical case after the complete denture was transitioned to IOD, the occlusal area and occlusal force were restored definitively. And it is interesting to note that the gravity center was stabilized in the middle. Objective methods to evaluate functional restoration through IOD will definitely need further study in the future.

### Denture border configuration of implant retained overdentures

#### 1. Differences of denture border configuration between complete denture and overdenture

As shown above, a clinical case was presented to transition a complete denture to IOD. In this case, a question was raised about whether or not the denture base contour and border should remain same as that of complete denture. Before responding to this question, differences of denture borders between complete denture and partial denture will be discussed.

The denture border of partial denture would follow that of complete denture as stated in the textbook. But the author would think that the border configuration should be different of course in consideration with the fact that the function of borders should not be the same.

First, in response to different function of borders, three typical patterns of dentures will be classified. (Fig35~37)

① Complete denture: Major function of denture border should be that of border sealing. By placing the border margin on the soft nature of mobile mucosa, the sealing is established to retain the denture in suction. (Fig.35)

② Free end denture saddle with multiple tooth loss: In case of multiple tooth loss and weak supporting tissues, there would not be sufficient if only with abutment

tooth retention or retaining effect. In compensation, therefore, the part of denture base needs retaining force from the border margin. So the border configuration would become close to that of complete denture. (Fig.36)

③ Free end partial denture with small number of tooth loss: In case of Kennedy Class I or II with, for example, missing first and second molars, there should be hardly necessary of marginal sealing. The denture base outline should be extended maximally on the residual ridge where least mucosal compression displacement is available, and no border is provided in the area where mobile mucosa is largely extended. (Fig.37)

However extensively the border is provided on mobile alveolar mucosa in constructing a complete denture, mucosal movement would not accompany much pain. This is because even when patient moves the mouth excessively, for example, in projecting tongue, one would unconsciously control the movement by dislodging a denture freely and avoid pain or ulcer beforehand.

But if any retention is established from the remaining teeth in such a case as ③, denture dislodgement would not occur easily in function. So in this case if any border is clearly defined on mobile mucosa, possible pain or ulcer might be caused in an excessive functional movement.

#### 2. What is the border configuration that requires for implant overdenture?

Description referring to IOD border configuration is rare in the past literature, but one literature states that denture base outline of IOD can be made minimum<sup>17)</sup> and, on the contrary, another refer that the border can follow the extension principle of complete denture.<sup>18)</sup>

McCracken teaches that a denture base should have sufficient area to distribute occlusal force, coined the term of the base as Snowshoe effect.<sup>19)</sup> As great magnitude of displacement and depression has been noted when the base

surface is small,<sup>20)</sup> IOD will also need the base outline with less displacement and depression. And so the base coverage is essential over the retromolar pad and buccal shelf.

The author thinks that the denture base outline necessary for IOD should follow those rules of partial denture. In other words, designs described above in ② or ③ can be applied selectively depending on implant placement site, its number and kind of attachment retainer.

As presented previously, in a clinical case where a complete denture is transitioned to IOD, functional improvement can be expected. Then the denture border with the complete denture as presented in ① will have to change into those presented in ② or ③ depending on retention magnitude of implant and degree of functional improvement. For that purpose, functional impression technique driven by patient under closed mouth condition might be appropriate.

In this case presentation, the complete denture that was used by the patient was modified and applied after the implants were placed. Consequently the denture base margin was maintained same as the complete denture and there happened frequent incidence of denture-oriented ulcer in the lingual frenum area. (Fig.38~40) This means that desired denture border configuration will have to vary according to changes of function.

Next, comparison was made to investigate what differences of denture border were possible on wearing the complete denture and after transitioned to IOD.

#### **Material and Method:**

Impression of both dentures of pretreatment (complete denture) and post treatment (IOD) were taken, and stone casts were made and sectioned, and cross section surface was observed. The measurement baselines were set at the median line (including lingual frenum, Fig.41A), first molar areas on both sides (Fig.41B, C) in longitudinal section vertical to the alveolar crest.

#### **Result and Discussion:**

In comparison with cut sections in the stone models of pretreatment and post

treatment, the labial to lingual distance was clearly decreased at the median line part (A). (Fig.42) When the models were compared to coincide at the alveolar crest height, the distance from the alveolar crest to the labial border remained unchanged. On the other hand, the distance from the crest to the lingual border became shorter.

Contributing cause and effect could be considered as follows. Probably the complete denture was dislodged when the tongue moved largely, and so the tongue activity was limited within a small range. But in case of IOD, it would not drop easily even if the tongue moved largely, and so the tongue activity range became more extensive.

Significant changes of the border width at the molar areas (B, C) were not observed between pretreatment and post treatment, (Fig.43) because the cheek muscle tissues running here were in an anteroposterior direction. And so it is considered that, even if there was some degree of muscle activity change, the border definition was not extensively influenced even through difference of the functional impression technique.

### **3. Features of border configuration of typical two- (or four-) implant overdentures (placed in the anterior arch)**

Followings are features of denture border configuration where two or four implants are placed in the anterior arch of an edentulous mandible.

- ① Median tongue frenum area: anterior part of denture retention should be mainly created with implant and attachment, and so the border seal under the sublingual salivary gland is not important. Therefore the configuration is made in a way that the tongue frenum movement should not be interfered. Advise to project the tongue on impression taking.
- ② Retromolar pad area: auxiliary support could be effected by covering the area.
- ③ Buccal side: buccal shelf should be covered for support if available. Keep the mobility of posterior

denture base in minimum. It should be shaped to provide the border sealing from this posterior base by leaning the buccal mucosa and the tongue together in neighboring front of the retromolar pad. <sup>21)</sup>

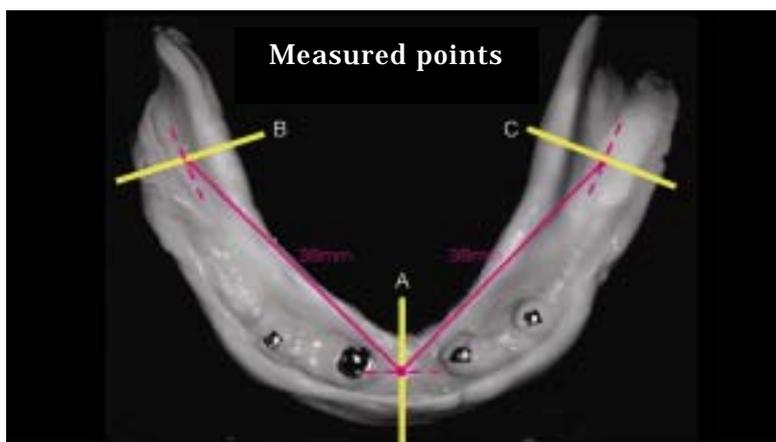
④ Mylohyoid line area: the lingual base flange is shaped to overstep the mylohyoid line in order to prevent Fishtail movement that is harmful to an implant body.

⑤ Buccal frenum area: it should be shaped in a way that the frenum movement is not interfered.

⑥ Labial flange: it should be shaped in a way that the mucous membrane activity is not interfered.

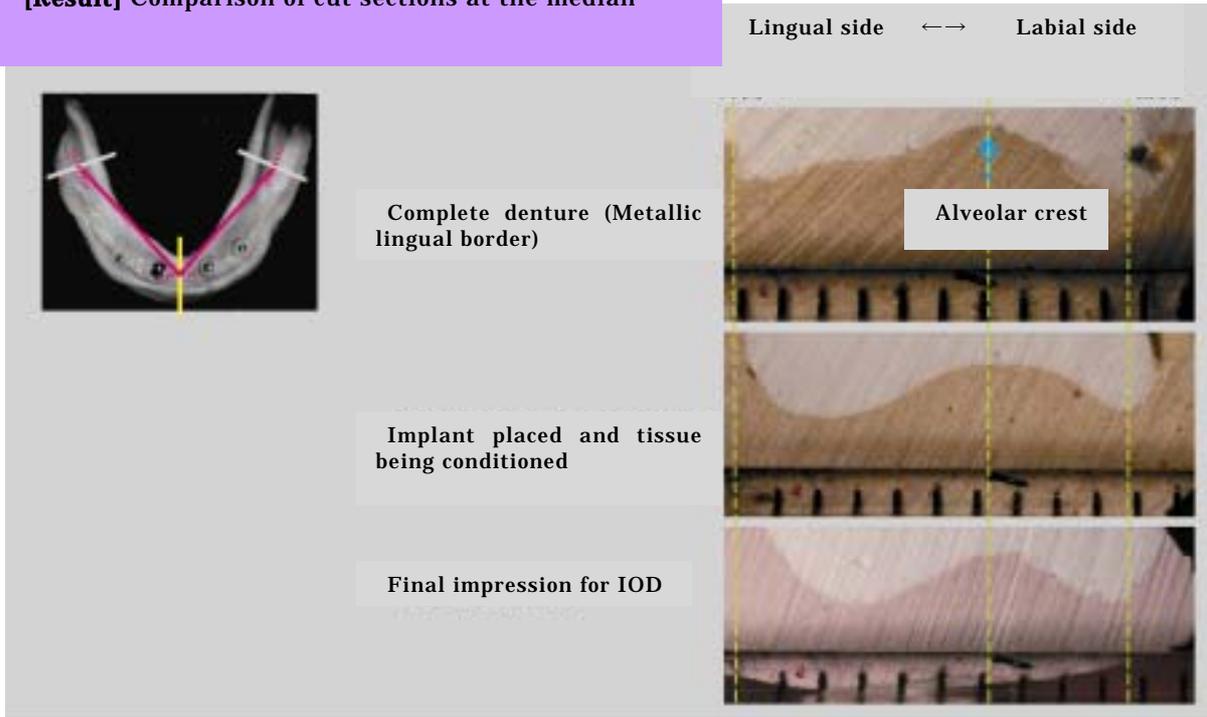


**Fig.38~40** After implantation, old denture was repaired and used in the healing period, but denture-oriented ulcer occurred frequently in the tongue frenum area. Originally the lingual border was finished with metallic plate, but it had no choice but to cut and reduce. Fig.40 (below) is a stable border configuration with the help of tissue conditioner.



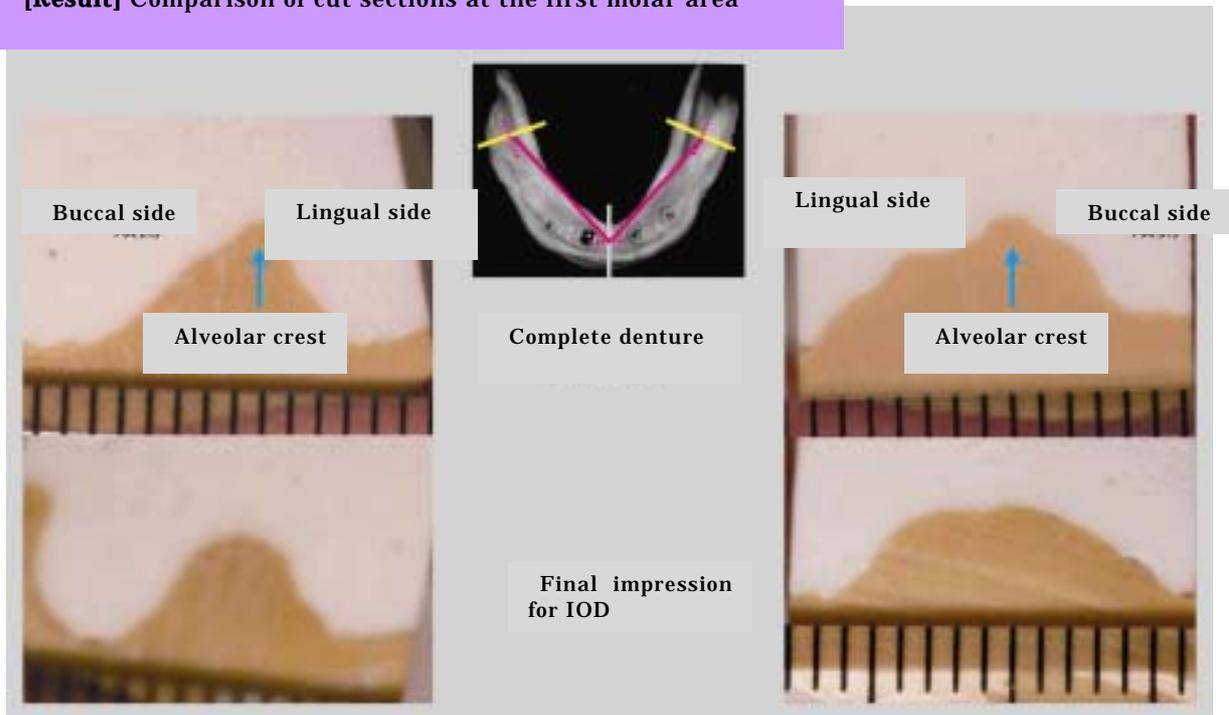
**Fig.41** Comparison study between pretreatment border configuration and IOD border. Stone models were sectioned after impression taken. 3 section sites were measured at the median line (including lingual frenum, A) and first molar areas on both sides (B, C).

**[Result] Comparison of cut sections at the median**



**Fig.42** The labial to lingual distance was decreased at the median line by changing into IOD. This area coincides with the lingual frenum part and especially the distance from the alveolar crest to the lingual border was reduced.

**[Result] Comparison of cut sections at the first molar area**



**Fig.43** Significant changes were not observed at the molar buccolingual distance.

## **Concluding remarks – Future views of implant retained overdentures**

### **1. Reduction of residual ridge – “Biological cost” by Zarb**

The author thinks that if patient is satisfied with pleasantly compatible denture, it is not necessary to venture an IOD. This will be agreeable to all.

But there is one thing which we should not overlook. That is an issue of reduction of residual ridge.

Even when a denture is pleasantly compatible, the ridge will resorb. In 1971 Atwood stated that force factor exerted by the denture base is attributed to one of causes of residual ridge reduction.<sup>22)</sup> Tallgren also reported that the period of tooth loss plays a definitive role to ridge reduction when long-term follow-up of complete denture wearers were studied.<sup>23)</sup>

Kalk et al. researched in 92 wearers of complete dentures the relationship of reduced amount of residual ridge against ① age, ② period of edentulism, ③ number of remade dentures, ④ wearing habit at night and day, stating that the bone resorption was connected with denture wearing period. And they also concluded that the existence of denture itself influenced on the magnitude of reduction of residual ridge.<sup>24)</sup>

Based on this background, Zarb advocated that denture wearing would lead to bone resorption and demonstrated the concept of “Biological cost”. Patients should be well kept with the information, that is, “Residual ridge reduction and bone resorption under removable plate dentures are what biological costs that patient must pay.”

On the other hand, in case of treatment with bone anchored bridge, it is known that residual ridge reduction can be rather decreased,<sup>25)</sup> and even in case of IOD, similar study of residual ridge reduction has been made. Kordatzis compared the posterior residual ridge reduction between wearers of complete denture and IOD, and he reported average values in 1.63mm for complete dentures and 0.69mm for IOD.<sup>26)</sup> Van Steenberghe, too, observed marginal bone loss around implants retaining IOD among 158 patients over the period of 12

years, and he reported that they stayed within average of 1.7mm of bone loss.<sup>27)</sup>

As suggested above, cases of IOD look difficult to evaluate within short period of time (not clearly visible), and this fact might have been reflected in the study. It is difficult for us to determine in what stage of period to intervene with placing implants before excessive resorption of residual ridge initiates.

### **2. Inflammation and force**

Keys to success of IOD will rest on the idea of “control of inflammation and force”, likewise as treating periodontal disease.

As far as inflammation is concerned, plaque control is vitally important, but it is difficult to maintain plaque control in IOD where denture plate covers placed implants. Normally in case of conventional overdenture supported by natural abutments, abutment tooth loss is often caused by its secondary caries rather than periodontal disease.<sup>28)</sup> In this respect, IOD is free from drawbacks of secondary caries, but plaque control is still vital in order to prevent implantitis.

As regards force, in case of IOD, denture design and provision of occlusion are influential to lateral force that is exerted toward implant body.

As for denture design, as described above, it is important to diagnose whether retention (marginal sealing) is to be achieved from denture base flange or alternatively major retention has to be accomplished from support. Denture base flange should be designed to attain immobility in the short term and, at the same time, it should be hard to displace in the long term run.

As for occlusion, IOD given to an edentulous patient should be viewed from both aspects of complete denture and of distal extension partial denture. In order to prevent from exerting lateral force to implant body, bilateral equilibrium occlusion is desirable like that of complete denture in order to minimize denture mobility in function.

And also IOD given to an edentulous patient often receives implant placement on the anterior part, thereby demonstrating presumably posterior

displacement like free-end partial denture. Likewise the dealing method of distal extension partial denture by Kantorowicz<sup>29</sup>), artificial teeth should be arranged in a way that occluding force should not be directed toward one third of base area distally from the placed implant.

### 3. Is Short Implant or Mini Dental Implant applicable?

In the McGill Consensus Statement, to an edentulous patient, two-implant retained IOD placed in the mandible could be the typical first choice of treatment. But there is no specific description regarding implant diameter and length that are desirable.

Meanwhile there appears a short type or thin type implant being introduced recently into clinics. (called Short Implant or Mini Dental Implant respectively) In this case presentation here, a thin type implant was used, but

evidence of confirming application of these implants for IOD is hardly established.

But when we see a ridge resorption case or minimally invasive case, we hope higher safety assurance and effectiveness of treatment. In this occasion, if rules of denture stability presented in this article are not strictly observed, and if appropriate denture border configuration is not correctly established, then excessive traumatic force will be exerted to the implant body only to fail the case. It should be remembered that IOD for an edentulous patient is absolutely based on prosthodontic treatment. The notion that an implant has to be added because complete denture was constructed but did not work is a hopeless case. The merit has in the idea that this is a treatment option in search of further functional improvement in addition to what gained from a complete denture.

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