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# Functional Assessment of Removable Partial Denture Before and After Short Implant Anchorage in Resorbed Distal Ridges: A Case Series

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## ABSTRACT

**Aim:** *The purpose of the study was to functionally evaluate removable partial denture in resorbed edentulism, before and after short implant anchorage.*

**Materials and Methods:** *13 patients, belonging to Kennedy Class I and II and rehabilitated with removable partial denture, underwent the insertion of one short implant in the resorbed distal edentulous ridge, connected to the removable partial denture with a locator attachment after osseointegration. Before the implant insertion and after the prosthetic connection the following tests were performed: psychological evaluations, prosthetic satisfaction questionnaires, kinesiographic recordings and masticatory efficiency test.*

**Results:** *Preliminary psychological tests revealed no signs of depression and a medium-high level of self-esteem. After implant anchorage, masticatory cycle's patterns became more uniform and with a decreased variability, due to the improved stability of the prosthesis; moreover, patients showed a statistically significant improvement in masticatory efficiency and prosthetic satisfaction increased in every aspect, showing a better adaptability and a more positive attitude towards the rehabilitation.*

**Conclusion:** *Within the limitations of this study, short implant retained removable partial denture in situation of resorbed bone ridges, allows improving patients' psychological comfort and satisfaction, enhancing the prosthesis retention and function.*

**Key words:** Prospective cohort study, Short implants, Removable partial denture, Kinesiograph, Masticatory efficiency.

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## INTRODUCTION

Partial edentulism is constantly increasing [1] the incidence of class I rehabilitation, which is the most frequent, has remained unchanged, while the incidence of class II has increased. Kennedy class I and II edentulism, more common in the elderly, may present with a different visco-elastic behavior under load between the mucosa and the abutment teeth, thus leading to unfavorable rotational movements of the Removable Partial Denture (RPD). As suggested by the scientific literature, the anchorage of a RPD to one or two standard implants in partial edentulism with distal edentulous ridges can definitely improve retention, support, stability and function, and the psychological comfort of the patient, while maintaining the residual structures by improving the trophism of the mucosa, enabling a more uniform distribution of loads and preventing further bone resorption [2-12].

## MATERIALS AND METHODS

All patients rehabilitated with a RPD at the Department of Prosthodontics of XXX from 2004 to 2011, and fulfilling the following eligibility criteria, were consecutively included in the study [13]. The protocol was drafted in accordance to the Helsinki Declaration and informed consent was obtained from each patient before the study. The inclusion criteria were as follows: presence of a Kennedy Class I or II rehabilitated with RPD (either mandibular or maxillary), presence of low bone quantity in the posterior ridges, but enough for placing 6-mm

long implants, willingness to undergo surgery for improvement of RPD stability, retention and support. Exclusion criteria were any systemic disease contraindicating implant rehabilitation (*i.e.* uncontrolled diabetes mellitus), previous or actual treatment with chemotherapy or radiotherapy or intravenous bisphosphonates, presence of Temporo-Mandibular Disorders (TMD), and smoking habits. The prosthetic state situation was checked and re-established as necessary in terms of occlusal contacts, extension and precision of the denture base and the retentive efficacy of the clasps. Every patient underwent orthopanoramic X-ray and Cone Beam Computed Tomography (CBCT) scans. The clinical protocol called for the insertion of one short implant 5 mm × 6 mm (NXFOS560, Biomet 3Itm) in the distal edentulous ridge to be connected to the RPD with an attachment after osseointegration. After three months of healing for mandibular implants and four months for maxillary ones the second stage surgery was performed. Platform matching protocol was carried out for all implants. Locator attachments (Biomet 3Itm) were used for the connection, ranging from 1 to 4 mm in height and 4 mm in diameter. Laboratory matrices were first applied to each prosthesis during the connection procedure and then changed to soft retention pink Teflon matrices [13]. The research protocol considered preliminary psychological evaluations, a prosthetic satisfaction questionnaire, masticatory cycle's analysis and masticatory efficiency test. With the exception of psychological evaluations, the other tests were carried out before implant insertion and repeated after implant placement, following the prosthetic connection.

***Psychological evaluations and patient related outcomes***

Patients were given two questionnaires on self-esteem and psychological wellbeing, which were completed in a private setting of the Prosthodontic Department. They were assured that their answers would be held in the strictest confidence to help complete and truthful self-reporting. These psychological measures included the Beck Depression Inventory test (BDI) and the Rosenberg self-esteem scale [14-21]. Proposed by Dr Beck in 1961, the BDI is probably the most reliable and adopted scale to evaluate depression. It is a self-report test with 21 multiple choice questions based on the most frequent attitudes and symptoms detected in depressed patients. A value less than 10 indicates non-depressed patients, while higher values/scores identify a depressive state. The Rosenberg self-esteem scale consists of 10 questions to which the patient has to answer using a scale from 1 to 4 that is from "I totally agree" to "I fully disagree". The patient's score is in the range between 10 and 40. The higher the score, the higher the self-esteem of the patient. Furthermore, before and after implant anchorage patients were asked to complete a prosthetic satisfaction questionnaire using a Visual Analogue Scale (VAS) from 0 to 10, such that 0 represented no satisfaction and 10 represented maximum satisfaction based on their own estimates. The questionnaire, consisting of 7 questions, covers 5 key issues that rate the level of comfort during function, the painfulness, the stability of the denture and the amount of time spent wearing the prosthesis.

***Kinesiographic recordings***

A kinesiograph (K7 Evaluation system TM Myotronics-Noromed, Inc.) and cube-shaped jellies, of 2 cm per side, prepared according to the Gunne' s modified protocol [22], were used to evaluate patient's masticatory cycles pattern on the sagittal and frontal plane. Kynesiograph allows recording mandibular dynamics tracking the position of a magnet applied on the lower incisors. The magnet motion is detected by a helmet fixed on the patient's head owing to changes in the field strength caused by the magnet movement. The kynesiograph is then connected to a computer provided with dedicated software so as to visualize the masticatory cycle pattern directly. During each trial, patients performed ten masticatory cycles chewing two jellies, and the test was repeated twice. The values of Maximum Opening (Max OP), Maximum Protrusion(Max PR), and Maximum opening passing through Centric Occlusion (Max CO).

***Masticatory efficiency***

Patients were invited to test their masticatory efficiency by breaking up a test food and measuring the level of food comminution following the Olthoff et al. protocol [23-25]. The test food consisted of small cubes (5-6 mm per side) of an ordinary impression silicone (Optosil Comfort putty/Xantopren Kulzer GmbH), prepared using a special metal grid. Each subject

was invited to masticate 17 cubes, the equivalent of 3 cm3 of material, making 60 chewing cycles, which may be considered to be within the recommended range of cycles required to reduce Optosil cubes homogeneously. The masticated food collected from the patient's oral cavity was sieved under a stream of water at constant pressure by means of 4 sieves, whose pore diameter was progressively smaller (8 mm, 5.6 mm, 4 mm, 2.3 mm); afterwards, the sieved food was collected, dried and weighted.

**Statistical analysis:** Data were analyzed using statistical analysis software (SPSS, v. 24.0 IBM, Chicago, IL). Clinical and patient-related data were first examined for normality with the Shapiro-Wilk test and if they did not achieve normality, analyses were performed using non-parametric methods. The intragroup changes in parameters were analyzed by means of the paired Student t-test (Max Op, Max Co) or Wilcoxon signed rank test (masticatory efficiency, patient-related outcomes, Max Pr) as appropriate. The significance level was at 5%.

## RESULTS

Figure 1 describes the patients' selection process. A total of 13 patients, 9 females and 4 males (mean age 58.2 ± 12.3 years, range 39 to 76 years) fulfilled the eligibility criteria and entered the study. Eight patients (61.5) had Kennedy Class I. Overall, 21 implants were placed. As regard psychological analysis, preliminary psychological tests revealed no signs of depression and a medium-high level of self-esteem. Table 1 shows patient related outcomes before and after RPD anchorage. The improvement of VAS scores was statistically significant for all items of prosthetic satisfaction questionnaires ($p<0.05$). All patients perceived increase in both the RPD stability and comfort with the implant anchored RPD. In 9 out of 13 patients pain decreased, while the other 4 did not experience pain either before or after the RPD anchorage. Twelve patients claimed an improved chewing ability, while for only one the perceived masticatory performance remained unvaried. Ten patients decreased cheek biting with the implant anchored prosthesis, while 3 did not bite their cheeks either before or after the RPD anchorage. In 6 patients the number of hours spent wearing the prosthesis increased, while in the other 7 it remained unvaried. Finally, 8 patients improved their speaking ability, while for the remaining 5 it was unchanged. Masticatory cycles pattern on the sagittal and frontal plane before (Figure 2a) and after (Figure 2b) implant anchorage were recorded and archived for each patient: the values of Max Op ($p=0.184$), Max Pr ($p=0.421$), and Max Co ($p=0.362$) slightly increased in all patients but the improvement was not statistically significant (Table 2).

Data on masticatory efficiency are reported in Table 3. Overall, patients showed a statistically significant improvement in masticatory efficiency. No improvement was detected in the second sieve ($p=0.552$), while the amount of food passing through the third ($p=0.006$) the fourth ($p=0.001$) and eventually collected ($p=0.001$) increased significantly.

**TABLE 1: Vas score analysis of the prosthetic satisfaction questionnaire. H stands for "number of hours spent wearing the prosthesis", cheek for "cheek biting". SD: Standard Deviation; IQR: Interquartile Range.**

| Variable | Before implant anchorage | | After implant anchorage | | P Value |
|---|---|---|---|---|---|
| | Mean (SD) | Median (IQR) | Mean (SD) | Median (IQR) | |
| H | 7.23 (2.83) | 6.00 (5.00-10.00) | 8.92 (2.06) | 10.00 (8.00-10.00) | 0.026 |
| Cheek | 3.46 (3.64) | 3.00 (0.50-6.50) | 0.15 (0.55) | 0.00 (0.00-0.00) | 0.005 |
| Eat | 5.31 (2.78) | 0.00 (5.00-7.00) | 8.08 (1.75) | 8.00 (7.00-9.50) | 0.003 |
| Pain | 4.08 (3.17) | 4.00 (0.50-7.00) | 0.23 (0.60) | 0.00 (0.00-0.00) | 0.008 |
| Comfort | 4.85 (3.02) | 6.00 (2.00-6.50) | 8.92 (1.49) | 10.00 (8.00-10.00) | 0.001 |
| Stability | 3.85 (2.88) | 5.00 (0.00-6.00) | 9.08 (1.04) | 9.00 (8.00-10.00) | 0.001 |
| Speech | 7.15 (1.95) | 8.00 (5.50-8.50) | 8.62 (1.45) | 9.00 (8.00-10.00) | 0.017 |

**Table 2:** Masticatory cycles pattern analysis before and after implant anchorage. SD: Standard Deviation; IQR: Interquartile Range; Max OP: Maximum Opening; Max PR: Maximum Protrusion; Max CO: Maximum opening passing through Centric Occlusion.

| Variable | Before implant anchorage | | After implant anchorage | | P Value |
|---|---|---|---|---|---|
| | Mean (SD) | Median (IQR) | Mean (SD) | Median (IQR) | |
| Max OP | 8.58 (2.77) | 8.90 (6.45-10.30) | 10.62 (4.66) | 10.10 (7.30-14.40) | 0.184 |
| Max PR | 5.70 (5.74) | 3.30 (2.05-8.05) | 5.91 (2.97) | 5.60 (3.20-8.40) | 0.421 |
| Max CO | 11.37 (3.28) | 11.80 (8.80-12.75) | 13.11 (4.63) | 12.20 (9.50-16.50) | 0.362 |

**TABLE 3: Masticatory efficiency before (pre) and after implant anchorage (post), showing the amount of test food passing through the sieves [2,3,4] and eventually collected [5]. SD: Standard Deviation; IQR: Interquartile Range.**

| PATIENT | Sieve 1 pre | Sieve 1 post | Sieve 2 pre | Sieve 2 post | Sieve 3 pre | Sieve 3 post | Sieve 4 pre | Sieve 4 post | Collected pre | Collected post |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 3,59 | 3,18 | 0 | 0,79 | 0 | 0,12 | 0 | 0,06 |
| 2 | 0 | 0 | 0,39 | 0,44 | 0,72 | 1,33 | 0,01 | 0,43 | 0,07 | 0,2 |
| 3 | 0 | 0 | 1,24 | 1,44 | 0,09 | 1,22 | 0,01 | 0,44 | 0,03 | 0,21 |
| 4 | 0 | 0 | 2,12 | 2,22 | 0,48 | 0,25 | 0,38 | 3,48 | 0,88 | 0,89 |
| 5 | 0 | 0 | 0,06 | 0 | 0,51 | 0,71 | 2,58 | 2,97 | 0,29 | 0,36 |
| 6 | 0 | 0 | 0,29 | 0,33 | 0,61 | 1,32 | 0,63 | 1,63 | 0,12 | 0,46 |
| 7 | 0 | 0 | 2,35 | 0,62 | 1,54 | 1,66 | 0,59 | 0,65 | 0,35 | 0,48 |
| 8 | 0 | 0 | 0,64 | 0,58 | 0,5 | 0,64 | 1,2 | 1,34 | 0,23 | 0,28 |
| 9 | 0 | 0 | 2,99 | 1,7 | 0,92 | 1,23 | 3,18 | 3,32 | 0,79 | 0,82 |
| 10 | 0 | 0 | 0 | 0,23 | 2,56 | 2,88 | 1,81 | 2,11 | 0,25 | 0,49 |
| 11 | 0 | 0 | 0,38 | 0,19 | 1,54 | 1,6 | 2,36 | 2,5 | 0,4 | 0,5 |
| 12 | 0 | 0 | 2,23 | 2,32 | 0,4 | 0,61 | 2,47 | 2,86 | 0,18 | 0,27 |
| 13 | 0 | 0 | 0,4 | 0,38 | 0,07 | 1,11 | 0 | 0,35 | 0,02 | 0,22 |
| Mean (SD) | 0 (0) | 0 (0) | 1.28 (1.22) | 1.05 (1.01) | 0.76 (0.73) | 1.18 (0.66) | 1.17 (1.16) | 1.71 (1.24) | 0.28 (0.27) | 0.40 (0.24) |
| Median (IQR) | 0 (0) | 0 (0) | 0.64 (0.33 - 2.29) | 0.58 (0.28-1.96) | 0.51 (0.25-1.23) | 1.22 (0.67-1.46) | 0.63 (0.10-2.41) | 1.63(0.43-2.91) | 0.23(0.05-0.37) | 0.36 (0.21-0.49) |

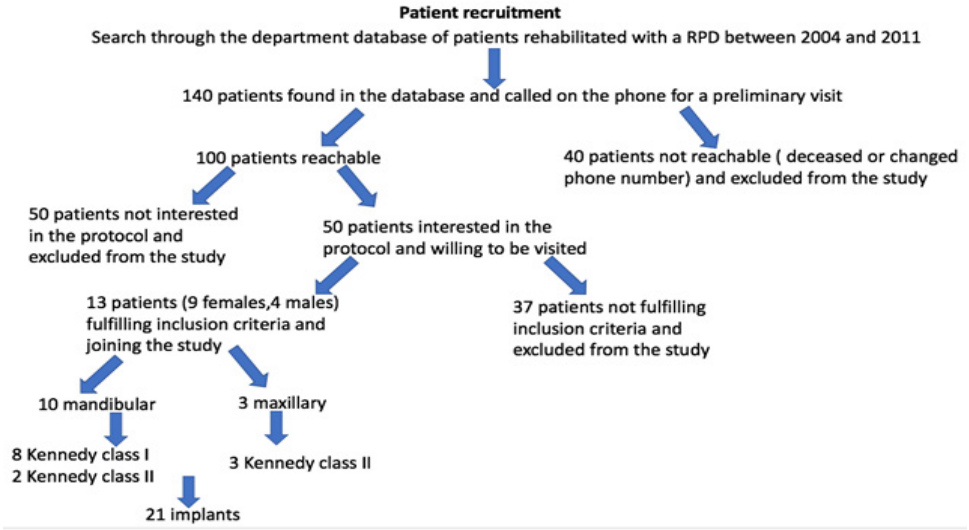


**Figure 1: Patient recruitment flow chart.**

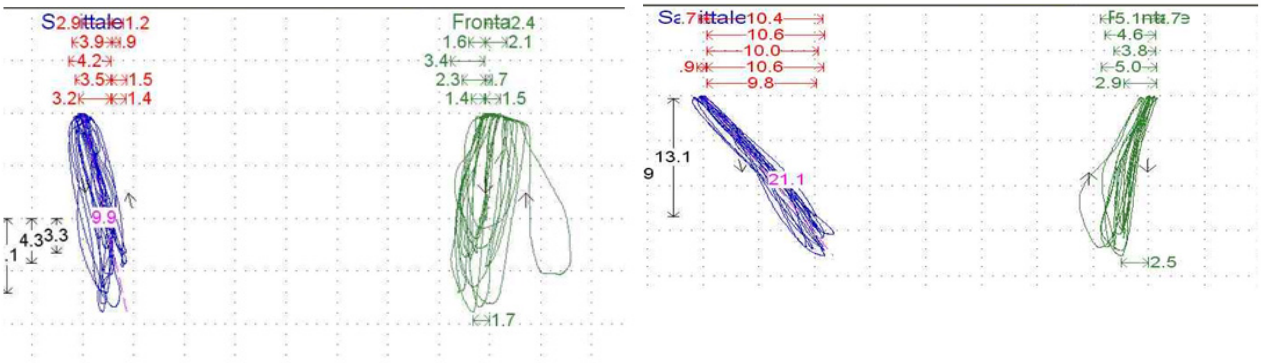

**Figure 2: Kinesiographic recordings on the sagittal and frontal view before (2a) and after (2b) implant anchorage.**

## DISCUSSION

Implant retained RPD is a viable treatment option that ensures the benefits of implant therapy, while keeping the advantages of a removable prosthesis, which is cheaper, easier to use, clean and repair, with high success rates both for the implants and the prosthesis. In the present study,

short implants were inserted: the use of short implants applies especially to patients with low vertical bone height, when complementary surgeries are not favorable, for saving time and minimizing patient discomfort, while simultaneously maximizing implant insertion in a strategic position. Psychological tests revealed no signs of depression and a medium-high level of self-esteem; therefore the patients' type of edentulism does not seem to be related to depression or low self-esteem. Moreover, these results excluded a possible negative interference of the psychological status on the prosthetic satisfaction questionnaire outcomes. As it can be inferred comparing the results of the satisfaction forms before and after implant anchorage, patients' satisfaction has increased in every aspect, showing a better adaptability and a more positive attitude towards the rehabilitation, besides the objective functional improvement. Both kinesiographic recordings and masticatory efficiency test were performed to support the clinical outcome, analyzing the functional changes occurring after implant placement, and to objectify patients' subjective perception revealed through the VAS score. Before implant anchorage all patients showed a masticatory cycle pattern similar to that of a dentate patient, that is drop shaped and with rather symmetric lateral movements, both on the right and left side. After implant anchorage, masticatory cycle's patterns have become more uniform and with an intra- and inter-subject decreased variability, due to the improved stability of the prosthesis, thus showing a progressive adaptation of the neuro-muscular system to the new rehabilitation. Kinesiographic exam was chosen based on the fact that it is repeatable, non-invasive, easy to perform and visualize, and it was successfully used in other studies to evaluate the changes occurring before and after implant anchorage [26-30]. During kinesiographic recordings, the recommended number of cycles provided by scientific literature 18 is 60: in our protocol the number of cycles was reduced to 10, due to the chewability of isinglass jellies that tended to melt by increasing the number of cycles. Patients showed a statistically significant improvement in masticatory efficiency: Just in a few weeks, the percentage of food that passed through the sieve increased, thus demonstrating the gradual improvement of the patients' masticatory efficiency, due to the better stability of the prosthesis, which allows for a wider mandibular range. Several techniques have developed throughout time to objectively evaluate masticatory function. Manly's technique [31] consisted of sieving masticated test food and it used to be the most adopted one. To simplify and accelerate this protocol, several test foods have been proposed, such as impression silicone [23-25,32,33] toasted nuts [34], colored chewing gums [35-37], paraffin wax [38], fuchsine fixed-jellies [39], rich in glucose jellies [40]. Olthoff' s protocol was adopted based on the fact that it is repeatable, precise and easy to perform.

## CONCLUSION

In the light of these preliminary data, anchoring distal extension RPD to short implants, with a resorbed ridge, seems to allow to improve patients' psychological comfort and satisfaction, enhancing the prosthesis retention and function. Kinesiographic examination and masticatory efficiency evaluation seem to be reliable tests to examine the changes induced by implant anchorage. Further investigations with longer follow-up period and a larger patients' sample will be useful to confirm and validate these data.

## AUTHORS'CONTRIBUTION

Author Elisabetta Bellia contributed to all the protocol steps, especially the experimental section, collected the data and contributed to the writing of the manuscript.

Author Guido Audenino contributed to the trial and performed the surgical operations.

Author Paola Ceruti contributed to the writing of the manuscript.

Author Federica Romano coordinated the data-analysis and contributed to the writing of the manuscript.

Author Francesco Bassi designed the research strategy, prepared the study and contributed to the writing of the manuscript.

## CONFLICT OF INTEREST

The authors reported no conflicts of interest to disclose related to this study.

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