Effect of implant assisted partial overdenture with neutral zone concept in partially resected mandible restoration on facial contour and bone density

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Abstract

This study was performed to evaluate the effect of implant assisted partial overdenture located in neutral zone for restoring partially resected mandible on facial contour and bone density.

Material and methods: 10 patients their age range from 18 to 45 years were selected. Each patient had partially resected mandible with osseous bone graft. Patients received removable partial overdenture assisted by two implants with suitable length and diameter guided by CBCT scan using early loading protocol two months after implant insertion. That partial overdenture respected neutral zone registration. Patients were recalled after two months from transitional partial denture insertion, two months after implant insertion and two months after implant assisting removable partial overdenture for facial symmetry evaluation, and assessment of bone quality. The data were collected, tabulated and statistically analyzed using test (ANOVA) with repeated measures comparing different follow up periods for bone density, and paired t-test comparing facial symmetry before reconstruction versus after reconstruction and mirror images to healthy side.

Results: Currently it was found that early loading protocol with two implants supported mandibular partial overdenture with neutral zone in reconstructed resected mandible produce implant success rates, and improve facial asymmetry.

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1. Introduction

Mandibular discontinuity most commonly occurs as a result of tumor resection. It may also occur as sequel of infection or trauma. Loss of mandibular continuity results in varying degrees of internal and facial change which cause impairment in appearance, mastication, speech, deglutition, self-image, and significant restorative problems. These occur through the loss of supporting structures, the presence of scar tissue, and irregular tissue topography. It may also produce non-repeatable mandibular movements and altered maxillo-mandibular relationships [1].

Several prosthetic options make the prognosis for these patients greatly improved. Rehabilitation with complete or partial dentures even when mandibular reconstruction is ideal may be difficult due to lack of stability or retention. The use of osseointegrated implants as a solution in these cases of mandibular defects has been accepted [2].

Implant supported overdenture achieves best hygienic maintenance, easy soft tissue follow up and low realizing cost [3]. The placement of dental implants requires meticulous planning and careful surgical procedures. A combination of a limited bone volume, poor bone quality and anatomical variations may lead to less predictable bone apposition and early implant failure. A thorough radiographic imaging assists in the therapy, preoperative treatment planning, surgical procedure, and in the postoperative assessment an ongoing implant function [4]. Cone Beam CT (CBCT) is an imaging technology that generates a 3D volume of image data which facilitate the accurate selection and location of implant [5].

Regarding the increase stabilization potential of rehabilitation for these patients neutral zone determination takes place. This physiologically based denture design concept has been shown to be effective for mandibular removable prostheses particularly patients affected by anatomic deformity or insufficiency through facilitating the development of vertical denture polished surfaces against which effective facial seal can be achieved and maintained [6].

Regarding the increase potential of facial appearance, data from various studies of facial symmetry have been collected using a variety of different materials and methods which change with the speeding progress of science from the beginning of old techniques of measuring such as spreading and sliding calipers, cephalometric radiographs and technique of anthropometry to a large variety of non-contact methods to measure three dimensional facial geometry such as laser scanning, stereo-photogrammetry, infrared imaging or computed tomography. However, most of these methods have inherent limitations [7].

Many methods have been proposed for mandibular reconstruction, most researchers evaluated the techniques. However few studies have focused on evaluation of facial contour for this reconstruction [8]. The study of implant assisted removable partial over denture located in neutral zone for partial mandibulectomy and their effect in facial contour restoration was considered as wide area of research [9]. Thus it was the aim of this study to evaluate the effect of implant assisted partial overdenture located in neutral zone for restoring partially resected mandible on facial contour and bone density.

2. Materials and methods

10 patients of 18—45 years have been selected from those admitted to Prosthodontic Department, Faculty of Dentistry, Tanta University. They all signed a written consent revised by the research ethical committee of Tanta University, to approve their agreement of being a part of the current research. All patients had a partially resected mandible with osseous bone graft (Fig. 1A). They were not subjected to chemotherapy or radiotherapy for at least one year before prosthetic treatment. Patients had their manual dexterity necessary to place and remove implant assisted prosthesis and to provide adequate oral hygiene around the implants. The prosthetic management of patients was done as: not.

2.1. Pre-operative analysis

Patients were subjected to radiographic examination by using Cone Beam CT scan of the mandible. Patient's photographs were taken in frontal views of each patient's face in the natural head position with a digital camera as a record for patients to be evaluated before prosthetic construction. Every partially resected mandible patient received conventional partial denture with neutral zone registration which then acted as pre surgical stent [6,9,15].

2.2. Implant insertion

In the partially resected side, all patients received two root form osseointegrated endosseous screw vent
type implants\textsuperscript{2} with suitable length and diameter which were determined by cone beam scan using Planmeca Romix® software. Implant received removable partial overdenture using early loading protocol as two months after implant insertion\textsuperscript{[10]}. This was done as:

At time of surgery, the oral mucosa and paraoral skin were painted and rubbed with antiseptic tincture to render the surgical field free from microorganisms. Gaining access to the operation field was made through a horizontal incision passing along the buccal side of the reconstructed mandible. The flap was reflected in both buccal and lingual directions using a periosteal elevator to expose the entire buccolingual width of the bone graft. The pilot drill was used to penetrate the bone graft to establish the proper location and angulations of the two implants fixtures. The bone graft sites were gradually widened and adjusted to fit the fixtures by means of specially designed drills of successively increasing dimensions.

The premounted fixtures were then placed in the prepared sites (Fig. 1B), first by finger, then by the ratchet wrench in a clock-wise direction. When the fixture has assumed its final position, the mount was loosened and removed with the hex driver. Fixture installation was then completed by applying the cover screw with the hex driver (Fig. 1C), to prevent bone from growing over the heads of the fixtures during healing, and by readapting the flap carefully by means of interrupted polyamide mattress sutures. A stress free healing period of two months was suggested to ensure a predictable physical union of the bone graft and implant fixtures\textsuperscript{[11]}. After healing period (two months) has been elapsed, the submerged implants were exposed as follows: The soft tissue covering the bone graft at the marked areas was locally anaesthetized and the cover screws were exposed through an incision flap. The cover screw were unscrewed and removed using the healing cap hex-driver in an anti-clock wise direction. The ball insert abutments were screwed in place with a ball insert abutment seating tool\textsuperscript{[11]}, (Fig. 1D).

\textsuperscript{2} Zimmer company, Germany.
2.3. Prosthetic rehabilitation procedures

The prosthetic procedures started about one week after the abutment connection where every patient received an implants retained metallic partial overdenture with a neutral zone technique. Primary impression of the mandibular residual ridge was made with Alginate impression material. Soon, the preliminary impressions were poured in dental stone, and the study casts were prepared. On the mandibular study cast, four main items were carried out: primary surveying, primary drawing of the design for a metallic RPD, construction of a custom tray with adequate spacer especially over the teeth and implant superstructures, charting of possible mouth preparation [12].

The suggested mouth preparations were then carried out in the patient mouth to receive the metal framework. The custom trays were fabricated with self-cure resin keeping the borders 2 mm short of the sulcus and green compound border molding was done. The assembled O ring housing was reseated on the implant abutment and an impression was made with an elastomeric impression material, then the assembly was removed again and kept aside. The secondary impression was poured in dental stone and a master cast was prepared and a record block was made. On the mandibular master cast, three main items were carried out; surveying to confirm the adequacy of mouth preparations, final drawing of the design for a metallic RPD, usual modifications of the master cast with a great attention paid to the relief at the implant site to provide enough space between the subsequent acrylic base and the implant superstructure.

The metallic removable framework was then fabricated using the standard technique for construction of a conventional metallic framework [12], (Fig. 1F). The metallic framework was tried in the patient’s mouth to ensure adequate seating of the framework. The implant assisted partial overdenture with neutral zone technique was done as follows [6]. The permanent base was prepared in heat cure resin. Hot red modeling plastic impression compound was applied to the record base to facilitate adhesion of the rim. In a water bath set to 60 °C, the edges of the recording rim were sealed to the record base using a heated spatula. The completed record base and recording rim was placed in the water bath for approximately 2 min in preparation for the clinical procedure. The base and rim was removed from the water bath and quickly placed intraorally. The patient was instructed to swallow. Next, a cup of warm water was provided to the patient and patient was instructed to sip and swallow. The patient repeated this sip and swallow exercise several times until the volume of the neutral zone record was detected. When the neutral zone record has cooled and hardened, excess modeling plastic impression compound displaced superior to the intended occlusal plane during the recording procedure was eliminated.

Then to develop the lingual neutral zone index, the neutral zone record was seated on the mandibular definitive cast. Laboratory putty was prepared to a workable consistency and was adapted into the tongue space of the neutral zone record. The template was positioned over the tongue space, and the putty was placed; the material was kneaded thoroughly, and was adapted to the record base, forming a recording rim. The edge of the recording rim was sealed to the record base using a heated spatula.

The completed record base and recording rim was placed in the water bath for approximately 2 min in preparation for the clinical procedure. The base and rim was removed from the water bath and quickly placed intraorally. The patient was instructed to swallow. Next, a cup of warm water was provided to the patient and patient was instructed to sip and swallow. The patient repeated this sip and swallow exercise several times until the volume of the neutral zone record was detected. When the neutral zone record has cooled and hardened, excess modeling plastic impression compound displaced superior to the intended occlusal plane during the recording procedure was eliminated.

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formed to the template to facilitate its placement during denture tooth arrangement, the facial index was developed as the same manner. Once polymerized, both the lingual and facial indices were removed and ensured that they can be replaced accurately and securely on the cast in the absence of the neutral zone record. The mandibular teeth were arranged within the neutral zone (Fig. 1H), as dictated by the facial and lingual indices [6].

In preparation for external impressions used to define denture polished surface contours within the neutral zone, carefully all base plate wax apical to denture teeth on the facial and lingual aspects of the mandibular trial denture and the facial and palatal aspects of the maxillary trial denture were removed. Required orofacial movements with the patient were practiced prior to making impressions. Low-viscosity impression material9 was applied on to facial aspects of the mandibular trial denture, and the trial denture was placed into the patient’s mouth (Fig. 1G). The patient was instructed to pucker the lips forward, smile broadly, move the mandible into protrusive posture, and then move the mandible from side to side. The patient repeated these movements several times. The trial denture was removed and the impression was evaluated. Excess impression material was trimmed and all material covering the denture teeth was eliminated. Finally, an external impression along the mandibular lingual flanges was made as the previous technique. The trial denture was removed and denture flange dimensions and extension was examined [6].

After the acrylic resin had polymerized, the denture was removed and examined for the orientation of the attachment in the denture to verify that the attachment was properly placed and secured [12], (Fig. 1I). The patient was instructed about the care of the denture and the oral hygiene procedures. The patient was then scheduled for both clinical and radiographic follow ups.

3. Results

Patients were called for any necessary adjustment and all the patients instructed to follow ups after two months of implant insertion and two months after implant assisting removable partial overdenture insertion for:

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9 Elite P&P Normal Set; Dentsply Caulk.
3.1. Facial symmetry evaluation and follow up

The facial symmetry evaluated by photo editing software for facial symmetry by using mirror imaging technique by creating a binary image for the actual facial image of patients then using Photoshop v7.0 software\(^{10}\) for measuring. The following 10 parameters (2 angle and 8 measurements of width), (Fig. 2) were measured with scale bar [9].

1. Distance between the bilateral exocanthions (BE; exr–exl)
2. Distance between the median line and the right exocanthion (m−exr)
3. Distance between the median line and lift exocanthion (m−exl)
4. Distance between the bilateral mouth corners (BMC; chr–chl)
5. Distance between the median line and right cheilion (m−Chr)
6. Distance between the median line and left cheilion (m−chI)
7. Distance between the bilateral exocanthions right and bilateral mouth right (BEr−BMC)
8. Distance between the bilateral exocanthions left and bilateral mouth right (BEI−BMC)
9. Angle (A\(^{\circ}\)) of the affected side between the horizontal line through the bilateral exocanthions (BE) and line through the bilateral mouth corners (BMCr)
10. Angle (A\(^{\circ}\)\)) of the healthy site between the horizontal line through the bilateral exocanthions (BE) and line through the bilateral mouth corners (BMCl)

3.2. Radiographic evaluation

Cone beam CT scan was used for assessment of bone quality and osseointegration for early loaded implant [13,14] (Fig. 3).

3.3. Statistical analysis

Statistical analysis were performed using a statistical software package SPSS.\(^{11}\) The data with conventional removable partial denture insertion and after its use and insertion of removable partial overdenture were collected, tabulated and statistically analyzed

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\(^{10}\) Adobe systems, Mountain View, CA.

\(^{11}\) SPSS release 16.0, SPSS Chicago 11.
using Paired t-test for comparison of facial symmetry between before reconstruction, after reconstruction and mirror images to healthy side and test (ANOVA) with repeated measures for comparing between different follow up for bone density.

The results of this study shaded a highlight on the ability of the implant assisted overdenture with neutral zone to improve facial asymmetry and ability to regain it to the main facial symmetry image by using these measurements of ten facial parameters. Photographs of faces investigate asymmetry before implant assisted prosthetic rehabilitation and investigate significant improvement in facial symmetry after implant assisted prosthetic rehabilitation, and the success of the implant assisted overdenture with neutral zone to correct the difference in regard to the main facial symmetry image. It was shown that there was significant correlation between the width of all parameters to explain this success results \((P < 0.05)\) except the angle between BE and BMC. However there was no correlation between the angle between the BE and BMC and the width of the various parameters \((P > 0.05)\). (Table 1), (Figs. 5 and 6).

This current study shaded also more light on bone density around the two implants in reconstructed bone in the resected side at the baseline and throughout study follow-up two months after implant placement and two months after implant loading with prosthesis. The result of this study showed significant improvement in bone density around two implants from the baseline, two months after implant insertion and two months after implant assisted partial overdenture with neutral zone concept. No significant difference between anterior and posterior implant in bone density during follow up period (Fig. 4).

4. Discussion

In this study implant assisted overdenture with neutral zone technique was used for rehabilitation of the partially constructed resected mandible due to implant-assisted overdentures requiring an appropriate cameo surface to prevent harmful forces from acting on the implant [15].

The neutral zone concept is useful for predicting the correct implant position. Techniques described here are intended to emphasize and illustrate the clinical value of recording the physiologic dynamics of oral and perioral muscle function and of using this information to develop denture contours and denture tooth positions. Arranging artificial teeth within the neutral zone achieves 2 important objectives: (1) prosthetic teeth do not interfere with normal muscle function; and (2) normal oral and perioral muscle activity imparts force against the dentures that serves to stabilize and retain the prostheses rather than cause denture displacement achieved by conventional denture used for those patients [15].

The objectives of the preoperative implant cone beam scan were currently included all necessary surgical and prosthetic information to determine the quantity, quality and angulations of bone; selection of the potential implant sites, and size (length and width) by Planmeca Romix software [14]. Early loading protocol was proposed in this study due to reduce overall treatment time, discomfort, increase high patient acceptance and better function [16]. In this study, a new method (measurement of horizontal angular facial asymmetry of the faces) [9] was used of hemi mandibulectomy patient by collating photographs of frontal view for a face by digital camera this required

Fig. 4. A. Bar graphs show comparison between bone density at the baseline, after two month of implant insertion and after two month of early loading in the implants. B. Comparison between bone density around anterior and posterior implant after two months of implant insertion and after two months of early loading.
orientation of the patient to be seated comfortably with Frankfort horizontal plane (external auditory meatus to orbital) parallel to the floor and with the head in a reproducible posture and at 1.5 m distance from the camera lens. The outer canthi of the eyes were used to form a baseline from which a midline could be constructed. A line was drawn connecting the outer canthus of eye. These particular points were chosen to form the baseline, because they are easily visualized on a frontal photograph and are relatively immobile. The baseline formed by connecting the canthi served as the major baseline for the construction of other baseline to measure the amount of deviation [9].

The result of this study showed significant change in angle of the affected side and angle of the healthy site before and after implant assisted overdenture. Also the significant change in distance between the bilateral exocanthions (BE; exr–exl), distance between the median line and the right exocanthion (m-exr), distance between the median line and left exocanthion (m-exl), distance between the bilateral mouth corners (BMC; chr–chl), distance between the median line and right cheilion (m-Chr), and distance between the median line and left cheilion (m-chl) before and after implant assisted overdenture, and the non-significant difference between this parameters

Fig. 5. Graph shows significant change in facial symmetry before and after reconstruction, with no significant difference between mirror image and after reconstruction indicating success in regaining facial symmetry.
after implant assisted overdenture and mirror images for patients. That mean there was correlation between the angle between the BE and BMC and the width of the various parameters \((P < 0.05)\), (Figs. 2 and 6). This study explained the findings that the orbits exhibited the degree, incidence of asymmetry and facial asymmetry which was in agreement with Rossi et al. [17], Haraguchi et al. [18] but that disagreed with Song et al. [9], who concluded that the orbits exhibited the lowest degree and incidence of asymmetry among individual structures of the face, whereas the mouth was the most asymmetrical, followed by the ear due to facial asymmetry is more exaggerated on the lower third of the face because of lateral deviation of the jaw.

The using of implant assisted overdenture with neutral zone correct the facial symmetry by regaining the soft tissue support to the reconstructed resected

Fig. 6. A, B, C Show: patient's face with asymmetry before any prosthetic reconstruction. a, b, c show patient's face symmetry after implant assisted partial overdenture with neutral zone insertion.
mandible and enhance oral function, without consuming time (early loading). That was accepted by Pekkan et al. [15] who concluded that the positive effects of the implant supported prosthesis with neutral zone technique are not only to accomplish the mentioned statements for the denture and the patient, but also to act as a critical determinant of facial profile.

Studies [13,19,20] have shown that density (quality) of available bone for implant placement is considered as factor influence the success of implant. Eckert et al. [19] and Young-Dai Song et al. [20] concluded that bone quality evaluated by CBCT has correlations with primary implant stability. This suggests that bone quality is one of the factors that require evaluation before implant surgery. In the literature [14,21,22], it was found that CBCT measurements considered accurate than CT measurements. However cone beam CT was used in this study to evaluate bone density around implant site throughout follow up period.

The significant improvement of bone density referred to implant success, parallel to Lekholm, Zarb, and others, [23–25] who concluded that sufficient bone density and volume are therefore crucial factors for ensuring implant success. Our study explained this result due to pre surgical evaluation of bone density by CBCT which indicate the type of bone in the selected site. The significant improvement of bone density after early loading of implant results in implant success which was explained by placement of implant in the neutral zone which prevents harmful forces from acting on implants.

5. Conclusion

This study concluded that: early loading protocol with two implants supported mandibular overdenture in reconstructed resected mandible produce implant success rates. CBCT scan is the best modality for preoperative planning, intra operative and postoperative assessment including all necessary surgical and prosthetic information to determine the quantity, quality (density) and angulations of bone; selection of the potential implant sites, and size (length and width). Recording of neutral zone as a part of the diagnostic work up before implant placement is important for improving the function and esthetic and regaining facial symmetry. Mandibular reconstruction using implant assisted overdentures with neutral zone correct facial asymmetry at a higher degree than before reconstruction.

The usage of implant assisted overdenture with neutral zone corrects the facial symmetry, enhances oral function, and improves the quality of life for many patients without time consuming of time. Regaining facial symmetry with the mandibular reconstructive procedure used is difficult to restore symmetry to the same level as can be found in the binary images but it decrease the difference between them. Although osseointegrated implants enable the solution of most obstacles in mandibulectomy cases, they are not usually providing the total answer to the removal of the compromises inherent in every case. The extent of the surgical resection, the location, quality of the remaining structures and patient’s desire for additional surgery may dictate the need to alter the basic principles usually applied.

References


