Immediate Rehabilitation of the Extremely Atrophic Mandible with Fixed Full-Prosthesis Supported by Four Implants

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ABSTRACT

Purpose: To prospectively assess the outcome of immediate rehabilitation of extremely atrophic mandibles by a full-arch fixed bridge anchored to four implants.

Material and Methods: Twenty patients with edentulous mandibles were included in the study. Each patient received a full-arch fixed bridge supported by two axial and two distal tilted implants. Prosthetic loading was applied within 48 hours of surgery. Patients were scheduled for follow-up every 6 months up to 2 years and annually until 5 years. Radiographic evaluation of marginal bone level change was performed at 1 year.

Results: All patients were followed for a minimum of 1 year (range 20–48 months, mean 30.1 months). No failures were recorded to date. The 1-year implant survival rate and prosthesis success rate were 100%. Marginal bone loss around axial and tilted implants was similar at 12-month evaluation, being, respectively, 0.6 ± 0.3 (standard deviation) mm and 0.7 ± 0.4 mm. High patient's level of satisfaction was recorded for function, phonetics, and aesthetics.

Conclusion: This technique could be considered a viable treatment option for the rehabilitation of the atrophic mandible.

KEY WORDS: atrophic mandible, dental implants, edentulous mandible, immediate loading, tilted implants

INTRODUCTION

In the last decades of the century, a demographic increase of the elderly population and a longer life expectancy have been recorded.[1]

The increased request for implant therapy results from a combination of various factors, including: age-related tooth loss, anatomic condition of edentulous ridges, psychological needs, decreased performance of removable prostheses, predictable long-term results of implant-supported prostheses, and increased awareness from both clinicians and patients of the benefits of implants.

Immediate loading of implant-supported full-arch prostheses for the edentulous mandible and maxilla is today a predictable procedure, associated with high level of satisfaction for the patients in terms of aesthetics, phonetics, and functionality.[2–9]

The rehabilitation of severely atrophic mandible using implant-supported prosthesis is often challenging because of the poor quality and quantity of residual jawbone, especially in patients with long-term edentulism. Most patients wearing complete dentures complain about progressive loss of stability during phonetics and mastication, and request for a fixed rehabilitation. Furthermore, progressive bone loss in the posterior mandible may lead to a superficialization of the alveolar nerve, which may cause pain to denture wearers during mastication. In the latter case, the placement of implants, even though of short length, in the posterior regions of the mandible may be contraindicated because

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of the risk of violating the nerve. Bone augmentation procedures could represent a solution for facilitating implant placement in the posterior mandible, but these types of intervention are poorly accepted by patients.

The combined use of axially placed and tilted implants represents another possible alternative for the treatment of the edentulous mandible, which has been documented in the recent years.[10–13] Implant inclination may be carefully planned by the surgeon in order to avoid damage to important anatomical structures. At the same time, with proper implant length and insertion axis, primary stability of the implants may be achieved, allowing immediate rehabilitation.

A fixed prosthesis supported by a low number of implants associated with immediate loading and possibly without experiencing edentulism could represent a satisfying treatment option for the patients.

The aim of this paper is to report the preliminary outcomes of a clinical study on immediate rehabilitation of extremely atrophic mandible using a fixed full-arch prosthesis supported by four interforaminal implants.

MATERIALS AND METHODS

This clinical prospective study was conducted according to the principles embodied in the Helsinki Declaration of 1975 for biomedical research involving human subjects, as revised in 2000.[14] All patients were informed on the purpose of the study and also of the possible alternative treatments and gave their written consent. They were treated in two different dental clinics. A single surgeon with considerable clinical experience with immediate loading procedures (E.A.) performed all the surgical operations.

Patient Selection Criteria

Inclusion criteria for the recruitment of the patients were:

1. 18 years or older of any race and gender;
2. Patients in general good health condition, able to undergo surgical treatment and restorative procedures (ASA-1/ASA-2);
3. Completely edentulous mandible or presence of teeth with an unfavorable long-term prognosis;
4. Adequate bone height and thickness in the interforaminal region for the placement of implants at least 10 mm long and 4 mm wide;
5. Presence of extremely atrophic posterior mandible (class IV–VI according to the classification proposed by Cawood & Howell[15]), in which the available bone height and width did not allow implant insertion without a preliminary augmentation procedure;
6. Patients who manifested a clear preference for a fixed implant-supported rehabilitation, but refused any kind of bone augmentation procedure; and
7. All fixtures could be placed with a final insertion torque of at least 30 Ncm

If one implant could not be placed with a torque ≥30 Ncm but the other fixtures reached this level of stability, immediate loading was still allowed. In case two or more of the implants did not achieve the required primary stability, all the implants were left to heal for at least 2 months before releasing the provisional restoration.

Patients were excluded for this study if any of the following criteria were present: acute infection at the implant site, hematologic diseases, serious problems of coagulation, diseases of the immune system, uncontrolled diabetes, metabolic diseases affecting bone, pregnancy or lactation, severe bruxism or clenching, irradiation of the head or neck region within the past 60 months, inadequate oral hygiene level, and poor motivation to maintain it throughout the study.

Preliminary screening was performed using panoramic orthopantomographs, computerized tomographic scans, and a careful clinical examination of the patient. All included patients were scheduled to be followed for up to 5 years after loading. In Figure 1 is shown a presurgical orthopantomogram of a fully

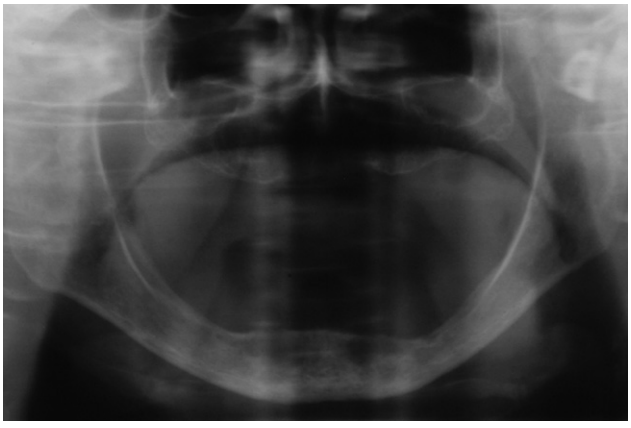

Figure 1 Preliminary panoramic radiograph of a fully edentulous patient with extremely atrophic posterior mandible. The closeness of the alveolar nerve to the posterior ridge can be noted.

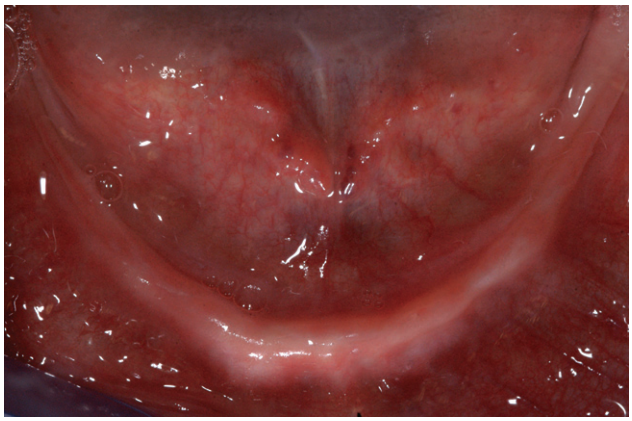

Figure 2 A picture of the mandible of the same patient soon before starting with the surgical procedure, showing the reduced width of the posterior ridge.

edentulous patient with atrophic posterior mandible that will be used as an example for describing the present technique.

Surgical Protocol

Starting 3 days before surgery and then daily for 7 days following surgery, chlorhexidine digluconate 0.2% mouthwash (Curasept®, Curaden Healthcare s.r.l., Milan, Italy) was prescribed to the patients. All surgeries were performed under local anesthesia with articaine chlorhydrate with adrenaline 1:100,000 (Alfacaina N, Weimer Pharma, Rastat, Germany) and intravenous sedation with diazepam (Valium® 5 mg, Roche, Milan, Italy). Patients were premedicated with 2 g of amoxicillin and clavulanic acid (Augmentin®, Roche, Milan, Italy) 1 hour prior to surgery and they continued with 1 g twice a day for 7 days postoperatively. Analgesic drug (Naprossene Sodico [Synflex Forte ®], Recordati, Milan, Italy) was prescribed postsurgery in case of pain.

Figure 2 is a picture from the clinical case soon before starting the surgical phase. The incision was started on the lingual side of the crest, in order to avoid the risk of damaging the alveolar nerve. The size of the incision was kept as smaller as possible in order to not compromise blood supply and to reduce patient discomfort. After reflection of the flap and identification of the mental foramina, the surgeon evaluated the length of the mental nerve loop and the shape of the bone with an atraumatic instrument.

All hopeless teeth, if present, were extracted and sockets were carefully debrided. Where necessary, a regularization of the edentulous bone ridge was performed with rotating instruments and/or bone forceps.

Each patient received four interforaminal implants (Brånemark System® MKIV or NobelSpeedy™ Groovy®, Nobel Biocare AB, Göteborg, Sweden). One implant was placed in the lateral incisor position and one near the emergency of the nerve for each side of the mandible. The two most distal fixtures were placed firstly (Figure 3). In order to engage as much bone as possible and to reduce the cantilever length of the prosthesis, implant site preparation was made tilting the drill distally by approximately 30 degrees respect to the occlusal plane, near the emergency of the alveolar nerve.

Finally, the two anterior implants were inserted axially (Figure 4).

During the early phase of drilling, the clinician evaluated bone density. The implant site could be slightly underprepared, avoiding countersink in order to achieve the highest possible implant stability.

A torque controller (Osseocare®, Nobel Biocare AB) with a torque limit of 50 Ncm was used for implant insertion and a manual wrench was employed in case of incomplete seating of the implant.

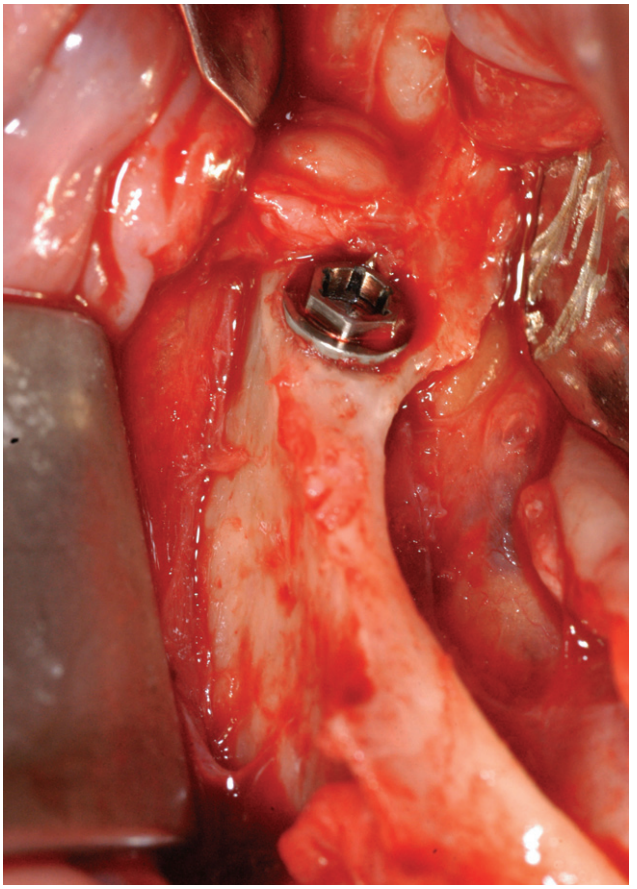

Figure 3 A picture of the distal tilted implant soon after placement.

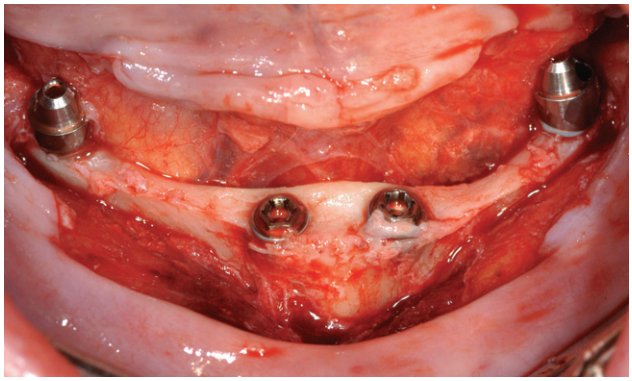

Figure 4 Intrasurgical view of the four implants after their insertion.

Multi-Unit Abutments (MUA®, Nobel Biocare AB) were connected to the implants. On distal implants, abutments angulated of 17 or 30 degrees respect to the long axis of the fixture were positioned to obtain an optimal orientation for the prosthetic screw access, while straight abutments were placed over the anterior implants. After positioning the coping, the soft tissues were sutured with a 5-0 resorbable suture (Monocryl or Vicryl, Johnson & Johnson Intl, St. Stevens Woluwe, Belgium) and an impression was taken utilizing a silicon putty polyvinilsyloxane (Elite Implant Impression Material, Zhermack®, Badia Polesine, Rovigo, Italy) directly on the coping. Then, four healing caps were placed upon the multi-unit abutments.

An acrylic temporary prosthesis with 10 teeth was delivered within 48 hours of surgery with centric and lateral contacts limited at the intercanine zone. A panoramic radiograph was made to check implant position and the coupling between prosthetic components.

After surgery, patients were instructed to avoid brushing and any trauma to the surgical site. Cold food was recommended for the first day and a soft diet for the first week.

After 4–6 months of loading, in the absence of pain and inflammatory signs, the patients received the final prosthesis, fabricated in acrylic by means of the CAD-CAM Procera® system (Nobel Biocare AB).

Data Collection and Follow-Up

Information on bone quality and quantity, implants characteristics, insertion torque, the presence of dehiscences or fenestrations were noted on apposite form at surgery.

The patients were scheduled for weekly control visits during the first month. During each visit, prosthetic functionality and tissue healing were assessed. Oral hygiene level was evaluated every three months in the first year.

Every 6 months for the first 2 years, and yearly thereafter up to 5 years, panoramic radiographs and, when possible, periapical radiographs, were taken, for the evaluation of peri-implant bone level change over time. Figure 5 is a panoramic radiograph taken at the 1 year follow-up, showing an overall stability of crestal bone levels.

During each follow-up visits plaque index and bleeding index were evaluated at implant level. Each implant was examined on four aspects (mesial, distal, vestibular, lingual), for a total of 16 sites per patient, as previously described.[13] Any site in which plaque could be detected by naked eye or with a probe, independent of the amount of plaque, accounted for 6.25% (1/16) of the total score (100%). The same was made for bleeding index considering positive any site that showed bleeding on probing.

Mobility of the prosthetic structure and occlusion were also checked. Any complication with the prosthetic components was recorded.

The patients' satisfaction for function, aesthetics, and phonetics was assessed by means of a questionnaire, delivered at the 6-, 12- and 24-month visit. The answers were based on a 5-point Likert-type scale, ranging from 1 ("poor") to 5 ("excellent"). Questionnaires were returned postage-paid.

At the 1-year follow-up visit, the prostheses were unscrewed and the stability of each implant was tested with the pressure of two opposing instruments.

The outcome measures evaluated for the present study were:

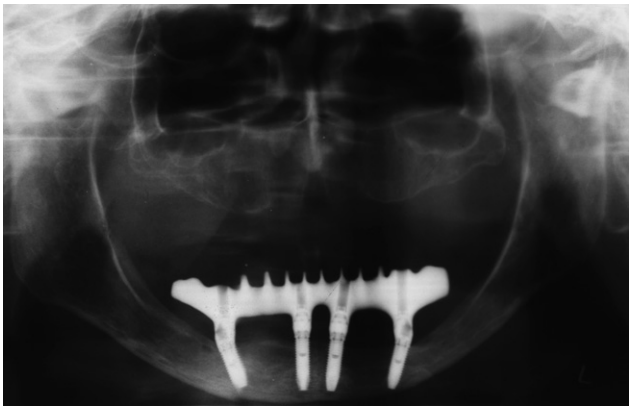

Figure 5 Panoramic radiograph after 1 year of follow-up, showing a general stability of the crestal bone level.

1. **Prosthesis stability**: when the prosthesis was in function, without mobility and pain. Prosthesis stability was tested by means of two opposing instruments' pressure.
2. **Prosthesis failure**: when the prosthesis had to be removed for any reason.
3. **Implant survival**: when there was no evidence of peri-implant radiolucency, no suppuration or pain at the implant site or ongoing pathologic processes and absence of complaint of neuropathies or persistent paraesthesia.
4. **Marginal bone level change**: Each radiograph was scanned at 600 dpi with a scanner (Epson Perfection Pro, Epson Italia, Cinisello Balsamo [MI], Italy) and the marginal bone level was assessed with an image analysis software (UTHSCSA Image Tool version 3.00 for Windows, University of Texas Health Science Center in San Antonio, TX, USA) by an independent blinded evaluator. Implant neck was the reference for each measurement. Mesial and distal values were averaged so as to have a single value for each implant. The peri-implant bone loss was calculated by difference between follow-up and baseline values of marginal bone level. Bone loss around tilted and axial implants was compared by using paired *t*-test. A $p = .05$ was considered as the level of significance.

RESULTS

From February 2005 to June 2007, 20 patients with severely atrophic posterior mandible (8 males and 12 females, mean age at surgery 60.8 ± 8.8 [SD] years, range 44–77 years), have been rehabilitated with an immediately loaded full-arch fixed prosthesis supported by four interforaminal implants. Four of them were smokers with an average consumption of 15 cigarettes per day. The opposing dentitions were: removable prostheses (11 cases), natural teeth and fixed prostheses on natural teeth (4 cases), implant-supported prostheses (5 cases).

A total of 80 implants were inserted: 12 Brånemark System® MKIV and 68 NobelSpeedy™ Groovy®. All fixtures had a diameter of 4 mm, while the length ranged from 11.5 to 15 mm. Thirteen of the implants were placed in fresh extraction sockets of seven patients. All implants could be inserted with a torque of at least 50 Ncm.

All patients received the provisional prosthesis as planned within 48 hours of surgery. No complication was recorded during surgical and prosthetic procedures.

The follow-up range was 20–48 months (mean 30.1 ± 8.6 months). At the time of this data reporting, 12 patients could be evaluated at the 2-year follow-up (Table 1). All subjects attended the scheduled follow-up visits. No implant failure was recorded to date, leading to a 100% cumulative implant survival rate. All the prostheses were stable and functional. No adverse event occurred.

Marginal Bone Level Change

Marginal bone level change around axial and tilted implants after 1 year of function could be evaluated at 72 implants in 18 patients. Twelve cases were evaluated using a panoramic radiograph and 6 using intraoral radiographs. Bone loss averaged 0.6 ± 0.3 and 0.7 ± 0.4 mm for axial ($n = 36$) and tilted ($n = 36$) implants, respectively. Such difference was not statistically significant ($p > .05$).

Other Parameters

A progressive decrease in plaque and bleeding scores was observed during the first year. Plaque index scores averaged 11.8 ± 4.9% and 8.1 ± 6.0% at 6 and 12 months,

TABLE 1 Life Table Analysis of Surviving Implants

Time Period, Months	Implants in the Interval (% of Total Implants)	Failed Implants in the Interval	Cumulative Survival Rate
Loading–6 months	80 (100)	0	100
6–12 months	80 (100)	0	100
12–18 months	80 (100)	0	100
18–24 months	80 (100)	0	100
24–36 months	48 (60)	0	100
36–48 months	12 (15)	0	100

TABLE 2 Plaque Index (PI) and Bleeding on Probing Index (BoP)

	6 Months	12 Months	24 Months
PI (%)	11.8 ± 4.9	8.1 ± 6.0	3.3 ± 2.7
BoP (%)	3.8 ± 4.1	2.0 ± 2.2	0.8 ± 0.6

Data are expressed as percentages as detailed in the text.

respectively. Bleeding index scores averaged 3.8 ± 4.1% and 2.0 ± 2.2% at 6 and 12 months, respectively (Table 2).

Eighteen patients filled in the questionnaire for satisfaction evaluation after 12 months follow-up (Table 3): aesthetics (teeth aspect and color, and smile appearance) was judged as excellent or very good by 66.7% of patients, while phonetics and mastication were considered excellent or very good by 77.8 and 88.9% of patients, respectively. The mean cantilever length for the final prosthesis averaged 15.2 ± 1.4 mm.

DISCUSSION

This study aimed at evaluating a technique for the rehabilitation of patients with severe atrophy of the posterior mandible. The preliminary outcomes for the patients treated indicate that such technique may lead to excellent prognosis, at least in the short term.

The loss of premolars and molars and the rehabilitation with complete denture or removable prosthesis for many years often lead to a severe alveolar bone atrophy in the retroforaminal zone, with superficialization of the alveolar nerve. This may imply increased pain and sorrow during mastication as well as a consistent reduction of the available bone, which is an unfavorable condition for the placement of implants according to a conventional protocol.

In these cases, the surgical procedure for implant placement must be designed according to the patient's anatomical condition of the posterior ridge. A conventional midcrestal incision could damage the nerve, increasing the risk of neuropathies, paresthesia, or anesthesia of the lower lip and chin. So, near the emergency of the nerve, the blade must be directed along the lingual side of the crest in order to avoid damaging the nerve. For these reasons, it is important to identify and isolate the nerve's foramen and carefully evaluate the course of the alveolar nerve by means of presurgical diagnostic imaging techniques.

For the rehabilitation of the totally edentulous mandible, especially in cases of extremely reduced posterior ridges, the ideal approach should aim at: minimization of the number of implants, reduction of the distal cantilever without compromising the functional support, avoidance of demanding bone grafting procedures, reduction of total treatment time and cost. The latter can be achieved by means of an immediate loading protocol. Overdentures also may represent a cost-effective solution for the immediate rehabilitation of the fully edentulous mandible. However, because of their partial mucosal support in the posterior regions, patients might experience pain as a result of compression of the retroforaminal zones during mastication.

The present technique is a modification of the "All-on-four" technique, previously proposed by Maló and colleagues.[11] The main difference is that only patients with severe atrophy of the mandible were selected for the present study. This required the insertion of the tilted posterior implants to be accurately planned and individually adapted. The axis of implant insertion was chosen according to the anatomical condition of the posterior mandible and the course of the mandibular nerve of each single patient. Another characteristic of

TABLE 3 Results of the Evaluation of Questionnaires for Satisfaction

	6 Months (20 Patients)	12 Months (18 Patients)	24 Months (12 Patients)
Function			
Poor	0	0	0
Sufficient	3	1	0
Good	1	1	1
Very good	12	13	9
Excellent	4	3	2
Aesthetics			
Poor	0	0	0
Sufficient	4	2	1
Good	5	4	3
Very good	10	10	8
Excellent	1	2	0
Phonetics			
Poor	0	0	0
Sufficient	1	0	0
Good	3	4	2
Very good	15	14	9
Excellent	1	0	1

patients with extreme mandibular atrophy is that, because of the thinness of the residual alveolar process, periapical radiographs were not always feasible owing to the impossibility of placing correctly the intraoral film. Therefore, in these cases, only panoramic radiographs were made and used for evaluating peri-implant bone loss. Even though the level of resolution of the periapical radiographs is greater than that of panoramics, if the latter are of good quality they can be equally used to measure the level of bone-implant contact as stated by some authors.[16–18] In the present study, the values of bone loss recorded from both radiographic techniques were very similar.

The analysis of the questionnaires for patient satisfaction demonstrated a high degree of acceptance for this type of treatment. Most of the patients included were denture wearers since long, seeking for a fixed rehabilitation. For them, the treatment provided in the present study represented the optimal solution, in terms of function, time, and overall cost.

The fully edentulous condition has usually a negative impact on the oral health-related quality of life, because of the chew impairment, poor phonetics, pain, and dissatisfaction with aesthetics.[19] Implant therapy often provides significant benefit to edentulous patients. The results of the present study are in agreement with other studies that investigated the quality of life of partially and completely edentulous patients after being rehabilitated with implant-supported fixed prostheses.[20,21] These studies, based on pre- and postoperative questionnaires, all reported improvement of the patient's quality of life as related to implant therapy.

It is possible that the favorable acceptance of the treatment and the excellent success rates recorded in the present study have contributed to the high proportion of the patients returning to each scheduled follow-up visit. A progressive decrease in plaque and bleeding index was also noted, reflecting a good compliance of the patients to oral hygiene instructions. In this instance, the role of the dental hygienist could be important not only for professional cleaning but also for its active role in patient's education and motivation.

CONCLUSION

The present immediate loading protocol can be regarded as a feasible technique for the rehabilitation of extremely atrophic mandibles in that both excellent mid-term clinical outcomes and full patients' satisfaction have been recorded. Long-term evaluation is needed to confirm the validity of this surgical approach.

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