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ORIGINAL ARTICLE

6 mm short versus 11 mm long inter-foraminal implants in the full-arch rehabilitation of edentulous non-atrophic mandibles: 5-year results from a multicenter randomized controlled trial

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Abstract

Objective: The aim of this multicenter parallel-group randomized controlled trial is to compare, in the same clinical scenario, 6 mm short with 11 mm long implants for the rehabilitation of completely edentulous non-atrophic mandibles.

Materials and Methods: Thirty patients in three study centers received a fixed full-arch mandibular rehabilitation supported by five inter-foraminal implants, with no need for bone augmentation procedures. Patients were randomly allocated (1:1 ratio), at the time of surgery, to test (6 mm implants) or control group (11 mm implants). After 3 months, a screw-retained full-arch prosthesis was positioned (baseline). Peri-implant marginal bone level change (MBLc, primary outcome) together with implant and prosthesis survival rate, and biological/technical complications (secondary outcomes) were evaluated up to 5 years.

Results: Twenty seven patients were controlled at 5 years (3 drop-outs). No implant or prosthesis loss occurred. No significant intergroup difference for biological/technical complications ($p > .05$, Fisher's exact test) and no significant intragroup and intergroup difference in the MBLc values were registered (test -0.03 ± 0.17 mm and control -0.13 ± 0.32 mm at 5-years; $p > .025$, one-sided Mann–Whitney U-test).

Conclusions: When used in comparable anatomic, surgical, and prosthetic conditions, no difference in the clinical and radiographic outcomes between 6-mm and 11-mm implants was observed at 5 years of follow-up. Short implants showed to be a reliable option for the rehabilitation of completely edentulous non-atrophic mandibles. There is growing clinical evidence supporting the use of short implants, even in the case of non-atrophic sites.

KEYWORDS
edentulous jaw, randomized controlled clinical trial, short dental implant

Marco Annunziata and Denis Cecchinato share the last authorship.

1 | INTRODUCTION

The use of short implants for the rehabilitation of atrophic sites in order to avoid the disadvantages of vertical bone regeneration procedures has greatly expanded in recent years and is supported by very promising clinical data showing similar high survival rates compared to longer implants for partial as well complete rehabilitations (Ravidà, Wang, et al., 2019; Thoma et al., 2015; Torres-Alemany et al., 2020; Toti et al., 2017).

The definition of "short implants" still remains quite controversial and has progressively changed over time, together with the improvement of the available techniques and materials, considering as "short" fixtures of length < 10 mm (Pommer et al., 2011), then ≤8 mm (Fan et al., 2017) and, more recently, ≤6 mm (Jung et al., 2018; Papaspyridakos et al., 2018; Ravidà, Wang, et al., 2019).

The comparison of short implants placed in healed sites vs. long implants placed in augmented, mainly posterior, sites are prevalent in the literature, whereas, as suggested by a recent Consensus report on this topic (Jung et al., 2018; Papaspyridakos et al., 2018), "randomized clinical trials comparing short and longer implants in intact bone sites without the need for vertical bone augmentation" are recommended for a correct comparison and to increase the body of evidence supporting the clinical efficacy of short implants. Several randomized controlled trials have been already conducted following this recommendation and encouraging results were obtained with the use of short implants in non-atrophic sites, although mostly short-medium term data are available (for review see Guida et al., 2022). If long term data, together with an accurate analysis of factors affecting clinical and radiographic implant outcomes, would corroborate such preliminary findings, we could hypothesize an extension of the clinical indications of short implants, with their intentional use also in sites where longer fixtures could be inserted. Short implants, indeed, offer some benefits that overcome those traditionally considered when they are used in atrophic bone sites. They guarantee less invasive surgery, ease of handling, and reduced risk of damaging anatomical structures, thus supporting the concept of a "stress minimizing surgery" (Nisand & Renouard, 2014). Furthermore, also if severe complications should happen over time imposing implant removal, the surgical procedure would be simplified, minimizing bone loss and increasing the chances for a new implant placement. These advantages become even more relevant when approaching to extended rehabilitations, where short implants have been shown to perform comparably to long implants, in terms of implant survival and marginal bone loss, especially when placed in the completely edentulous mandible and supporting fixed prostheses (Liang et al., 2022).

We have previously shown (Guida et al., 2020) the comparable clinical performance of short vs. longer implants in the rehabilitation of the edentulous non-atrophic mandible at 1 and 3 years of follow-up. Hereby, we present the 5-year results of this multicenter, parallel-group randomized controlled clinical trial aimed to evaluate the efficacy of 6 mm short implants compared with 11 mm long implants in comparable anatomic, surgical (no need for bone augmentation procedures) and prosthetic (fixed full-arch mandibular prosthesis) conditions. In particular, the null hypothesis was that there was no difference in terms of marginal bone-level change (MBLc) between short and longer implants from prosthetic installation to 5 years of follow-up.

2 | MATERIALS AND METHODS

2.1 | Study design and general information

This study was designed as a multicenter parallel group randomized controlled clinical trial (RCT) with a 1:1 allocation ratio. It was reported according to the CONSORT statement (http://www.consort-statement.org/; Figure 1). Three Italian centers participated in the study: the Department of Dentistry of the University Hospital "Luigi Vanvitelli," Naples (leading center), the Hospital "A. Cardarelli" of Naples, and a private office in Catania (Dr. Paolo Torrisi's office). The Declaration of Helsinki principles were followed, and all patients signed a written informed consent form. The research protocol was approved by the ethical committee of the University of Campania "Luigi Vanvitelli" (Aut. N. 13/2010) and registered on a public RCT database (clinicaltrials.gov NCT03509402). The CONSORT flow diagram of the research protocol is shown in Figure 1.

2.2 | Primary and secondary outcomes

The primary outcome was the radiographic MBLc expressed as the change of MBL from prosthetic installation to the follow-up.

The secondary outcomes included: (i) implant survival rate, (ii) prosthesis survival rate, and (iii) biological or technical complications. Surviving implant or prosthesis was considered those still in function at the follow-up. Biological complications included peri-implant mucositis, defined as a reversible inflammation of the soft tissues surrounding an implant in function with no loss of supporting bone, and peri-implantitis, defined as an inflammatory process affecting the tissues around an osseointegrated implant in function resulting in loss of supporting bone (Renvert et al., 2018; Zitzmann & Berglundh, 2008). Technical complications were categorized into minor and major complications. The formers require only chair-side repair and included screw loosening and veneer material fracture. The latter requires additional laboratory procedures and/or replacement components and included prosthesis or framework fracture, screw fracture, implant fracture, and extended wear requiring veneer renewal.

2.3 | Sample size calculation

Sample size calculation revealed that group sample sizes of 13 per group achieved 80% power to detect non-inferiority using a

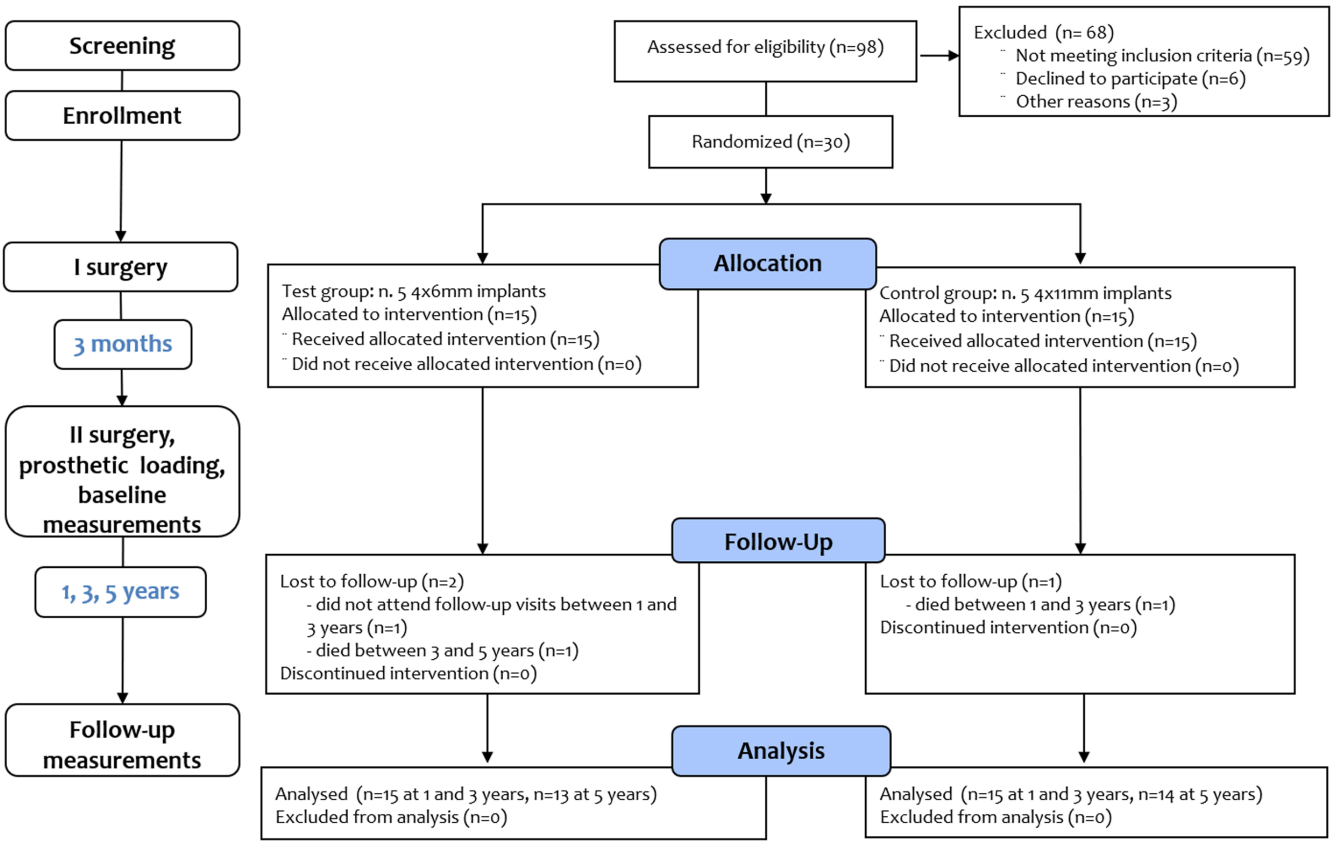

FIGURE 1 CONSORT flow diagram of the research protocol.

two-sample, one-sided test. The margin of noninferiority (δ), which is the threshold value judged as clinically relevant, was 1.0 mm. The true difference between the means was assumed to be 0.0. In consideration of the one-tail nature of the noninferiority test, the significance level (alpha) was set at .025. The data were drawn from populations with standard deviations of 0.9 and 0.9. Such a value was based on the long-term marginal bone loss data from the population of mandibular edentulous patients rehabilitated with Toronto bridges supported by conventionally loaded inter-foraminal long implants (Ekelund et al., 2003). Fifteen patients per group were recruited to compensate for possible drop-outs.

2.4 | Patient enrollment

Patients were enrolled at the three involved centers. Inclusion criteria were age between 18 and 75 years, total mandibular edentulism for at least 8 months, sufficient amount of native bone (no previous bone augmentation procedures) in the inter-foraminal area to host 11 mm-long and 4 mm-wide implants with ≥1 mm of bone at the buccal and lingual aspects and ≥3 mm of interimplant distance (determined by computed tomography), systemic health and compliance with good oral hygiene. Exclusion criteria were any disease, medication or drug that could jeopardize healing, osseointegration or treatment outcome, severe bruxism or other parafunctional habits, and unrealistic esthetic demands. Smoking habit was registered as heavy smoker (≥10 sig./day), light smoker (<10 sig./day), nonsmoker, or former smoker. Patient eligibility in terms of bone dimensions was determined on computer tomography (CT) scans, with the aid of an implant planning software (Simplant, Dentsply Implants NV, Hasselt, Belgium).

2.5 | Preparing and planning phase

Eligible patients received a complete anamnestic and clinical examination; hopeless teeth were extracted and remaining teeth were periodontally and restoratively treated, if needed. A 15% cutoff for full-mouth plaque score and full-mouth bleeding score was requested for dentate patients. The prosthetic project was accurately planned on cast models mounted in an articulator. When possible, the previous denture was used as a reference.

2.6 | Randomization and allocation concealment

The randomization and the allocation concealment were carried out using a computer-generated randomization list and sealed sequentially numbered opaque envelopes by a person not otherwise involved in the study (C.N.). Envelopes were consecutively opened at the leading center and communicated to the surgeon at the first surgery.

2.7 | First surgical phase

Implant positioning was performed by expert clinicians (one per center: L.G., U.E., P.T.), following the same shared surgical protocol. A computer-aided bone-supported pilot surgical guide (Simplant pilot guide, Dentsply Implants NV, Hasselt, Belgium) was used during implant placement. All patients were treated under local anesthesia using mepivacaine or articaine with adrenaline 1:100,000. A full-arch crestal incision, with distal releasing incisions if needed, was performed, and full thickness flaps were raised. The mental nerves were visualized and isolated. Five parallel implant sites were prepared by calibrated burs and five 4 mm-wide implants (OsseoSpeed TX, Astra Tech Implant System, Dentsply Sirona Implants, Mölndal, Sweden) were installed anterior to the mental foramens following the outline described by the manufacturer. A 6 mm-long implants and 11 mm-long implants in the test and control groups were placed, respectively. A minimum of 3 mm of interimplant distance and 1 mm of bone at the buccal and lingual aspects were required, with no need for augmentation procedures (if augmentation was required, the patient would have been excluded from the study). If needed, an osteoplasty of the alveolar ridge was done by means of a carbide cutting bur mounted on a straight surgical handpiece. The implant head was placed flash to the bone (Figure 2). At the end of the surgical procedure cover screws were positioned and a careful adaption of the flaps by means of an accurate suture was assured in order to obtain primary closure and full periosteal coverage.

2.8 | Postoperative care

The patients were instructed to rinse with a chlorhexidine 0.12% mouthwash twice a day for 2 weeks and to avoid using the denture. Liquid and semisolid food was prescribed for the first postoperative week, after which the sutures were removed. Two weeks after the surgery, the denture was properly relined avoiding direct contact with the fixture until the second-stage surgery. Patients were controlled at 4, 8, and 12 weeks.

2.9 | Second surgical phase and prosthetic procedures

After 3 months of healing all implants were exposed by separated linear incisions, cover screws were removed and replaced by healing abutments. After 1 week, the final abutment (Uni-abutment, Astra Tech Implant System, Dentsply Sirona Implants, Mölndal, Sweden) was screwed on each implant and an abutment-level impression was registered. Expert clinicians (M.A., M.S. and P.T.) followed all the prosthetic phases. All patients received a fixed screw-retained full-arch prosthesis with distal cantilevers (Figure 3). It consisted of a cobalt-chrome framework, fabricated according to the Cresco method (Dentsply Sirona Implants, Mölndal, Sweden) covered by an acrylic veneer. The length of the bridge cantilevers was calculated to minimize implant overloading (Mericske-Stern et al., 2000). All prosthetic procedures were made according to the Astra Tech Implant System procedures and products manuals.

2.10 | Supportive peri-implant therapy

Patients were instructed in proper hygiene measures, suitably designed and based on their individual needs, including tooth brushing, interdental brushing, flossing, and rinsing with an antiseptic mouthwash. Patients were recalled every 6 months for a control visit and professional supragingival ultrasonic debridement and polishing.

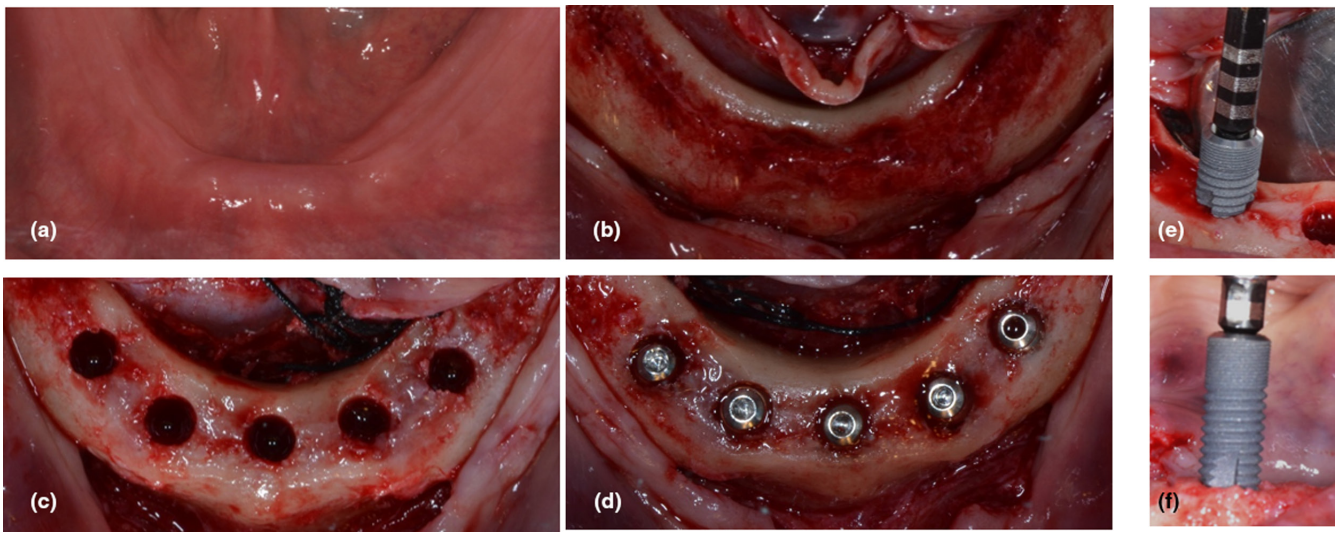

FIGURE 2 First surgical phase. Edentulous arch (a, b), implant sites (c), implants positioned (d), test (6 mm) and control (11 mm) implants (e, f).

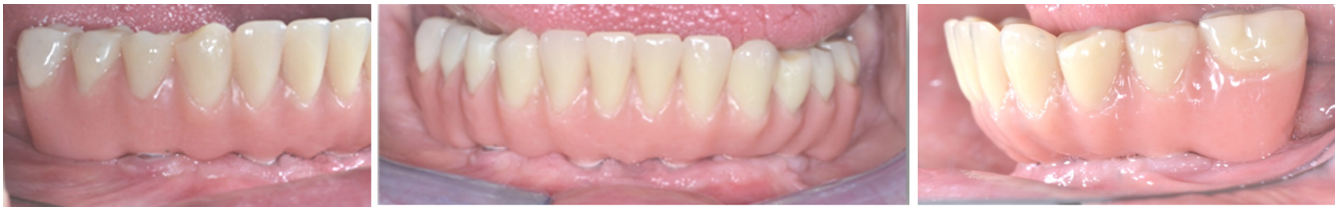

FIGURE 3 Fixed screw-retained full-arch prosthesis in place.

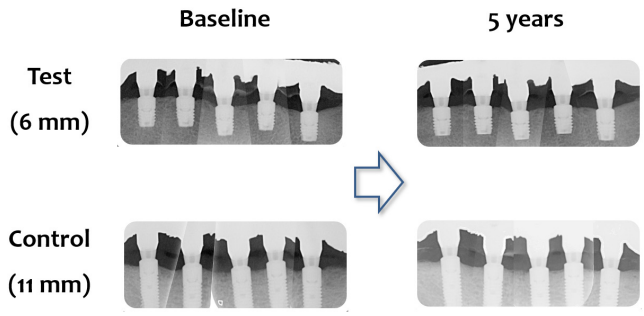

FIGURE 4 Periapical radiographs at the baseline and at the 5-year follow-up of test (6 mm) and control (11 mm) implants.

2.11 | Baseline and follow-up examinations

Radiographs and clinical examinations were performed, together with primary and secondary outcome assessment, at baseline (final restoration placement), and after 1, 3, and 5 years of loading (Figure 4).

Clinical examination included visual inspection to detect signs of inflammation as well as the occurrence of technical complications. Peri-implant probing depth, the presence of visible plaque, and bleeding/suppuration on probing around implants were also evaluated.

Peri-apical radiographs were taken with Rinn Universal Collimator (Dentsply RINN, York, PA, USA) to limit exposure levels and Rinn film holders (XPC Extension Cone Paralleling System, Dentsply RINN, York, PA, USA), for correct positioning. Film-holder's position was noted down for each implant site to increase reproducibility. The MBL was determined (ImageJ 1.48a, National Institutes of Health, Bethesda, MD, USA) as the distance between the top of the micro-thread implant region and the most coronal level of the bone-to-implant contact, using inter-thread distance for calibration. All the radiographic measurements were performed by an experienced examiner (A.P.) not otherwise involved in the study, who was kept unaware of the implant length by duly masking the radiograms. Mesial and distal MBL were measured at each fixture, and the MBLc from the baseline was calculated at each follow-up (negative values in case of bone loss). Mean values were calculated at the implant, patient, and group level.

2.12 | Statistical analysis

Descriptive statistics (means, standard deviations) of continuous variables and relative frequencies of discrete variables were computed for each group separately using a statistical software program (OpenStat, http://openstat.info). Data were analyzed by an examiner (M.A.) blinded to the experimental groups using the patient as the statistical unit unless differently specified. Intention-to-treat (ITT) analysis was adopted. The Fisher's exact test for discrete intergroup variables and the one-sided Mann–Whitney U-test for MBLc values were applied because of the nature of the data. For primary outcome, statistical significance was set at the alpha level of .025 using a one-sided test, while for two-sided tests statistical significance was set at the alpha level of .05.

3 | RESULTS

Thirty patients were enrolled from July 2011 to July 2015 and allocated 15 to the test and 15 to the control group. The demographic characteristics of the enrolled patients are listed in Table 1. More female patients were enrolled in the test group ($p = .02$, Fisher's exact test), no intergroup difference at the baseline for any other of the considered variables was found.

A total of 150 implants (5 per patient, 75 per group) in 30 patients were inserted. Between the 1-year and the 5-year follow-up, two patients (test) died and one patient (control) did not attend control visits, so that 13 test and 14 control patients were re-evaluated at 5 years. No implant or prosthesis failure was registered (100% survival rate in both the test and control groups). Eight implants (5 test, 3 control) in four patients (2 test and 2 control) suffered from peri-implant mucositis, resolved by professional cleaning and 1% chlorhexidine gel application every week for 1 month. One control implant suffered from peri-implantitis between 4- and 5-year follow-up, treated and solved following the cumulative interceptive supportive therapy protocol (Mombelli & Lang, 1998) without need for surgical treatment. No other biological complications that required additional chair-time were observed. In five patients (4 test, 1 control), one acrylic tooth fracture per patient was registered and repaired. Three cantilever fractures, occurred in one test (after 1 year of function) and in two control patients (after 2 years of function), were repaired by laser welding after prosthesis removal. Two of these patients had natural teeth, and one had a removable denture at the opposing arch. In two patients (1 control, 1 test), the acrylic veneer was renewed due to wear after 4 years of function. Both of them wore removable denture at the opposing arch. No other technical complications that might require chair-time or additional laboratory procedures and/or replacement components were observed.

No significant intergroup difference for the registered complications was found (Fisher exact test). Biological and technical complications occurred are summarized in Table 2.No statistically significant differences ($p > .025$) in terms of MBLc between baseline and follow-up visits in each group, as well as between test and control groups at all follow-up visits, were observed. MBL and MBLc mean values with standard deviations at baseline and 5 years are reported in Table 3. Figure 5 shows MBLc values in form of box plots reporting minimum, first quartile, median, third quartile, maximum, and outliers for the test and control groups at 5 years. To estimate the correlation of measures on the primary outcome within centers the intraclass correlation coefficient (ICC) was calculated and the estimated value showed a very low correlation of the measures (ICC = 0.08). Furthermore, a sensitivity analysis was performed considering the center effect. A mixed-effect regression model was fitted considering MBLc as independent variable, group as covariate, and center as random effect. In this model, a nonsignificant effect of the group was found ($p = .364$) with an estimated difference between the two groups (test vs. control) of 0.09 (95% CI [−0.10 to 0.28]).

When the mean MBLc value, at 5 years of follow-up, was expressed in terms of cumulative frequency distribution with the patient used as statistical unit, no significant difference was observed between the test and the control group. About the same percentage of both test (61.5%) and control (64.3%) patients lost (up to 1 mm) bone and about the same percentage of both groups gained (up to 0.5 mm) bone (38.5% and 35.7%, respectively). When the implant was used as statistical unit, some differences emerged (Figure 6). 40% of 11-mm implants and 33.8% of 6-mm implants exhibited marginal bone loss during the 5-year post-loading period. A significantly higher rate of implants experiencing marginal bone loss >1.0 mm in the 11-mm group (8.6%, 6/70) compared to the 6-mm group (0.0%, 0/65) was found ($p < .01$, Fisher's exact test). Five out the six control implants with >1.0 mm of bone loss belonged to five different patients (one implant per patient, except for one patient who contributed with two implants, lost >1.0 mm of bone), so that no clustering effect could be assumed. 31.4% of 11-mm and 30.8% of 6-mm implants exhibited no MBLc. Finally, 35.4% of test implants and 28.6% of control implants showed bone gain (up to 1 mm).

TABLE 1 Baseline patient characteristics.

	Test (6 mm)	Control (11 mm)	Total	*p*
Number of patients (implants)	15 (75)	15 (75)	30 (150)	NS
Mean Age ± SD	63 ± 6.3	61 ± 8.6	63 ± 7.5	NS
Gender (Male: Female)	5:10	12:3	17:13	.02*
Smoking habit				
Heavy smokers (≥10 sig./day)	3	4	7	NS
Light smokers (<10 sig./day)	0	0	0	NS
Non-smokers	10	9	19	NS
Former smokers	2	2	4	NS

Abbreviations: NS, not significant; *p*, p-value (Mann–Whitney U-test or Fisher exact test); SD, standard deviation.

*Statistically significant.

4 | DISCUSSION

The present RCT compared the performances of short (6 mm) and long implants (11 mm) placed in the inter-foraminal area supporting a fixed screw-retained full-arch mandibular prosthesis with distal cantilevers. All the enrolled patients had mandibles able to host five inter-foraminal 11-mm-long and 4-mm-wide implants, with at least 1 mm of peri-implant bone circumferentially, without requiring augmentation procedures. Such restrictive inclusion criteria were chosen in order to compare the results of short

TABLE 2 Biological and technical complications.

	Test (6 mm)	Control (11 mm)	Total	*p*
Biological complications				
Peri-implant mucositis (implants/patients)	5/2	3/2	8/4	NS
Peri-implantitis (implants/patients)	0/0	1/1	1/1	NS
Total (implants/patients)	5/2	4/3	9/5	NS
Technical complications				
Veneer fractures (prostheses/patients)	4/4	1/1	5/5	NS
Prosthesis/framework fractures (prostheses/patients)	1/1	2/2	3/3	NS
Wear requiring veneer renewal (prostheses/patients)	1/1	1/1	2/2	NS
Total (prostheses/patients)	6/6	4/4	10/10	NS
Total biological and technical complications (implants or prostheses/patients)	11/7	8/5	19/12	NS

Abbreviations: NS, not significant; *p*, *p*-value (Fisher exact test).

TABLE 3 Marginal bone level values and changes at baseline and 5 years of follow-up. Data expressed in millimetres as mean ± standard deviation (patient level).

	n	T0	*n*	T5	ΔT0–T5	*p* (vs. T0)
Test (6 mm)	15	0.26 ± 0.23	13	0.30 ± 0.31	−0.03 ± 0.17	NS
Control (11 mm)	15	0.31 ± 0.30	14	0.40 ± 0.23	−0.13 ± 0.32	NS
p (vs. control)		NS		NS	NS	

Abbreviations: *n*, number of patients; NS, not significant; *p*, *p*-value (Mann–Whitney U-test); T0, baseline; T5, 5 years; Δ, marginal bone level change, negative values indicate bone loss.

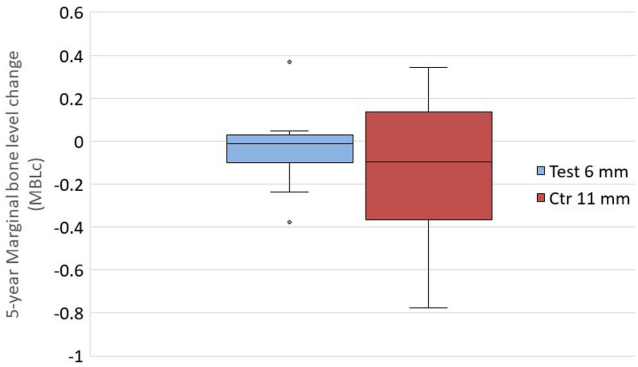

FIGURE 5 Box plots of the 5-year values of marginal bone level change of the test (6 mm implants) and control (11 mm implants) group reporting minimum, first quartile, median, third quartile, maximum and outlier values (patient level).

and long implants avoiding the possible influence of anatomical, surgical, or prosthetic factors. Five years results show no differences between test and control groups in terms of MBLc, implant/prosthetic survival rate, and biological or technical complications occurrence, showing excellent performances of both 6 mm and 11 mm implants.

Implants were all positioned in healed sites with a type IV surgical timing (Hämmerle et al., 2004); they were left submerged for 3 months and, afterward, exposed to be connected to the final prosthesis with a conventional loading (Weber et al., 2009). Such a protocol has the longest and consolidated literature validation compared to other types of implant-supported rehabilitations (Adell et al., 1981; Adell et al., 1990; Brånemark et al., 1995; Ekelund et al., 2003; Zarb & Schmitt, 1990), thus representing a prudent choice for the rehabilitation of completely edentulous mandibles.

Several studies compared short and long implants both positioned in non-atrophic sites (Barausse et al., 2019; Cannizzaro et al., 2015; Cannizzaro et al., 2018; Felice et al., 2016; Guljé et al., 2013, 2021; Romeo et al., 2014; Rossi et al., 2016; Storelli, Abbà, et al., 2018; Weerapong et al., 2019; Zadeh et al., 2018). Lower short implant survival rate after 5 years of function is reported in those studies, with values ranging from 86.7% (Rossi et al., 2016) to 96.2% (Romeo et al., 2014), compared to the present one (100%), where no implant, neither prosthesis, failed. However, some differences exist with our protocol that, to the best of our knowledge, remains the first randomized study comparing short and long implants in fully comparable anatomical, surgical, and prosthetic conditions. The majority of the aforementioned studies focused on implants placed in the posterior jaws supporting single or 2–3 splinted crowns (Guljé et al., 2021; Romeo et al., 2014; Storelli, Abbà, et al., 2018; Weerapong et al., 2019), and only one study (Cannizzaro et al., 2018) investigated complete edentulism rehabilitated by full-arch prostheses. In that case, however, for the rehabilitation of completely edentulous mandibles, 4 inter-foraminal implants were placed and immediately loaded. Furthermore, several deviations from the original protocol were reported by the authors (e.g., implants placed distally to the mental foramina, post-extraction implant insertions, and the occasional use of implants with a diameter larger than anticipated).

In the present RCT, the MBLc registered up to 5 years of follow-up was very limited in both test and control groups, even if the cumulative frequency distribution of MBLc showed a trend for higher marginal bone loss for long implants compared to short ones. These results were comparable to those reported by other studies, that, similarly to the present one, measured MBLc considering the prosthetic loading as baseline; in fact, the majority of the available RCTs showed no significant differences in MBLc between short and long implants at the 5-year follow-up (Guljé et al., 2021; Romeo et al., 2014; Rossi et al., 2016). Only one study showed a significantly higher mean MBLc in the long implant group at 5 years (Cannizzaro et al., 2018), and, in another one (Guljé et al., 2021), a higher rate of long implants (8.7%) experiencing a > 1 mm marginal bone loss compared to short implants (3.3%) was reported. However, any comparison appears difficult in consideration of the significant differences in the study protocol among the studies.

The same difficulty can be encountered comparing data on technical complications found in the present study, with those reported by systematic reviews including prospective studies carried out on fully edentulous patients rehabilitated with cantilever-fixed implant-supported restorations (Papaspyridakos et al., 2012; Storelli, Del Fabbro, et al., 2018). The total amount of technical complications was not provided in those studies. Looking at the data provided on the single types of complications, some heterogeneity could be found. For instance, the rate of veneer wear in the present trial was similar to those reported in the above-mentioned studies, whereas the rate of framework fractures was higher, and the rate of veneer fracture/chipping was lower. The reason for such discrepancies can be related to the absence of uniform case definitions and evaluation criteria among the studies. Furthermore, there are a number of variables, such as the design of the study, patients' habits, characteristics of the opposing

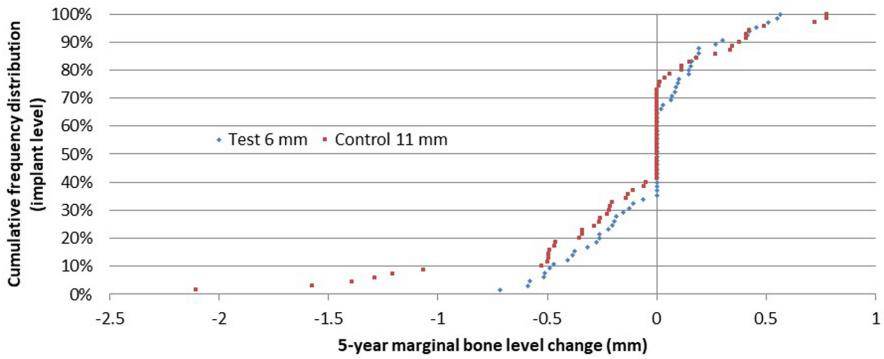

FIGURE 6 Cumulative frequency distribution of marginal bone level changes (mm) from baseline to the 5-year follow up. Each dot represents the mean (mesial and distal) marginal bone level change for each test (6 mm) or control (11 mm) implant.

dentition, prosthesis extension, location, fixation, and materials, that may significantly affect the amount and types of complications registered.

The implants used in the present RCT had a moderately rough surface, which has been widely demonstrated to have a positive effect on the prognosis of short implants with respect to the unmodified surfaces used in the past (Nisand & Renouard, 2014). This may have contributed to obtain the excellent clinical and radiographic results of short implants. Furthermore, also implant location may have played a role for the good results, since inter-foraminal mandibular area is commonly related to good bone quality. Mandibular short implants, indeed, usually present higher survival rate compared to maxillary ones (Pommer et al., 2011; Srinivasan et al., 2014). This, somehow, may limit the generalization of the results of the present RCT, since the maxilla is more frequently characterized by a lower bone quality, and caution should be placed in using short implants in those areas (Nisand & Renouard, 2014; Renouard & Nisand, 2006; ten Bruggenkate et al., 1998). Finally, the strict respect of the scheduled visits for supportive periodontal and peri-implant therapy (Mombelli, 2019) every 6 months may have contributed to the low incidence of biologic complications that was in line with literature data from prospective studies on the same type of rehabilitation (Storelli, Del Fabbro, et al., 2018).

Among the possible limitations of the present study, there was the absence of standardized radiographs. Although care was taken to correctly position the film holder and the X-ray tube, inaccuracies in the radiographic measurements cannot be excluded and this aspect must be considered in data reading and interpreting. The medium-term follow-up (5-years) may be considered another limitation, although all patients will be followed over time and longer follow-up data could be available thereafter.

Short (6 mm) implants showed clinical and radiographic outcomes, up to 5 years of loading, comparable to those of longer implants (11 mm), thus representing a reliable option for the rehabilitation of completely edentulous non-atrophic mandibles. Although further data with a longer follow-up and a larger sample size from well-designed RCT are needed to provide clear evidence and sound clinical recommendations, these preliminary results support a very promising hypothesis of the routine use of short implants, even in the case of non-atrophic sites, supporting the concept of a minimally invasive and simplified implant therapy, with absolute benefits for both patients and clinicians.

AUTHOR CONTRIBUTIONS

Luigi GUIDA: Conceptualization (lead); data curation (equal); formal analysis (equal); funding acquisition (lead); investigation (equal); project administration (lead); writing – original draft (lead); writing – review and editing (lead). **Umberto Esposito:** Data curation (equal); investigation (equal); writing – review and editing (equal). **Massimiliano Sirignano:** Data curation (equal); investigation (equal); writing – review and editing (equal). **Paolo Torrisi:** Data curation (equal); investigation (equal); writing – review and editing (equal). **Marco Annunziata:** Conceptualization (equal); data curation (equal); formal analysis (equal); investigation (equal); supervision (lead); writing – original draft (lead); writing – review and editing (lead). **Denis Cecchinato:** Conceptualization (equal); data curation (equal); formal analysis (equal); supervision (lead); writing – original draft (equal); writing – review and editing (lead).

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CONFLICT OF INTEREST

Luigi Guida reports grants from Dentsply Sirona Implants related to the submitted work (Investigator-Initiated Study D-2009-010). Marco Annunziata reports grants from Dentsply Sirona Implants related to the submitted work. Denis Cecchinato reports personal fees and grants from Dentsply Sirona Implants, outside the submitted work. The other authors declare no potential conflict of interest with respect to the authorship and/or publication of this article.

DATA AVAILABILITY STATEMENT

Data available on request from the authors

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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