KEY WORDS
Implants, Hybrid prosthesis, Cast metal framework, Electric welding

Randomized controlled trial

INTRAORALLY ELECTRICALLY WELDED *VERSUS* CAST METAL FRAMEWORKS FOR SCREW-RETAINED IMPLANT-SUPPORTED MAXILLARY PROSTHESES: ONE-YEAR POST-LOADING DATA FROM A SPLIT-MOUTH RANDOMIZED CONTROLLED TRIAL

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PURPOSE. To compare the clinical outcomes of electrically welded *versus* cast frameworks for screw-retained implant-supported maxillary prostheses.

MATERIALS AND METHODS. Twelve patients with edentulous maxillae received six implants each. After four months of unloaded healing, shaping abutments were connected to the implants on one randomly selected side, and titanium wire was bent and attached to the implants by intraoral electric welding (EWF). A cast metal framework (CMF) was constructed on the other side. The fit between the implant abutments and their respective prosthetic abutments was assessed at the framework try-in stage. Then, both cast and welded frameworks were picked up in the complete maxillary denture after modification. Patients were followed up to one year after loading. Outcome measures were: prosthesis and implant failures, complications, peri-implant bone loss, and passive prosthesis fit.

RESULTS. No patient dropped out and no prosthesis or implant failed. CMF was associated with a higher rate of complications (P = 0.16); RD: -0.25; 95% CI: -0.60 to 0.10) than EWF, but the difference was not statistically significant. One year after loading, the CMF group had lost an average of 0.97±0.15 mm of peri-implant bone vs. 0.43±0.28 mm in the EWF group. This difference was statistically significant (mean difference = -0.54 mm, 95%CI -1.03, -0.31, P = 0.005). All 12 EWF prostheses were passive, while eight CMF (67.3%) prostheses were passive, and 4 were not (33.3%). The difference was statistically significant (P = 0.02; risk difference -0.33, CI 95% -0.05 to -0.61).

CONCLUSIONS. Electrically welded implant-supported framework could be a superior treatment option compared to conventional cast framework as it seems to be associated with less peri-implant bone loss and better passive prosthesis fit.

CONFLICT OF INTEREST STATEMENT
The authors have no conflict of interest to declare.

INTRODUCTION

Conventional complete dentures have long been an option for edentulous patients' oral rehabilitation. These patients experience various issues, such as poor denture retention and stability, chewing difficulties, low self-esteem, and a decreased quality of life and satisfaction[1,2]. Fixed implant-supported maxillary prostheses reduce the issues the patient encounters with removable complete dentures; they have high success rates, and increase the patient's self-esteem[3,4]. Furthermore, implant splinting a metal framework provides a firm connection for better stress distribution and stability for the overlying prosthesis; indeed, the incidence of implant failures in splinted implants supporting prostheses is lower than in non-splinted ones[5-7].

In this context, the cast metal framework is that most commonly used as it is the construction method technicians are most familiar with. However, it requires multiple impressions, waxing and metal casting, all of which could affect the final framework fit and lead to mechanical complications such as screw loosening, screw fracture or framework fracture, as well as biological complications such as mucositis or peri-implantitis. These complications increase the need for maintenance and repair[6].

Many other techniques have been developed for metal framework construction, including milling or printing the framework using CAD/CAM technology. Although these may help overcome the issue of misfit and hence decrease complication rates, unfortunately these procedures are expensive and rely on sophisticated devices. Another solution is electric welding of the framework intraorally. This can eliminate the costly and time-consuming impression-taking process, along with its inherent inaccuracies[7], and the weld strength produced is comparable to a dental technician's laboratory laser[8].

Laser welding has long been used in the lab to join metal pieces of dental restorations. This procedure is superior to traditional techniques since it may be performed directly on the master cast, decreasing lab construction errors and welding close to resin or ceramic pieces, without any damage or restoration fatigue. Electrically welded connections also have high, reproducible strength. Moreover, because the beam is restricted to a small area, temperature fluctuations do not induce deformities or stress to implants or the surrounding structures. It has been reported that the laser-welded titanium approach displays superior passive fit, reducing the stresses on the implant-bone interface and resulting in less peri-implant bone resorption[7].

A recent systematic review revealed that the laser-welded framework has greater stress distribution properties than cast ones. Welding is the most effective at obtaining relatively low values of marginal misfit, resulting in better precision[8]. Nonetheless, there are some limitations to this approach: it is not helpful for every type of metal or alloy, it cannot be used on patients with pacemakers, and does not work with filler metals. In addition, some of the energy from the welding process, centred between the two electrodes, dissipates into the adjacent field[8].

The main issue regarding screw-retained frameworks is how to achieve passivity. Passive fit means the adaptation should be accomplished without tension on the retaining screws. A perfect passive fit is currently extremely difficult, especially for screw-retained prostheses, and a misfit of 30 to 150 µm has been deemed clinically acceptable[9,10].

No randomized controlled trials have yet compared outcomes of cast and electrically welded frameworks. Hence, this study aimed to determine whether the screw-retained implant-supported prostheses built on electrically welded metal frameworks have a different effect on implant failure rate, complications, peri-implant bone loss and passive fit in comparison to cast frameworks.

This trial followed the recommendations made in the CONSORT Statement for reporting within-person randomized clinical trials[11].

MATERIALS AND METHODS

Trial design

In this split-mouth randomized controlled trial, each half-arch of each patient's maxilla was randomly assigned to either EWF or CMF. Maxillary screw-retained implant-supported prostheses were constructed over six implants. One side received an electrically welded framework (EWF), and the other received a cast metal framework (CMF). The Cairo University Faculty of Dentistry Research Ethics Committee approved the study protocol as number (8-4-20). The study protocol was registered at ClinicalTrials.gov, ID: NCT04548258.

Participants

The inclusion criteria were completely edentulous patients aged >18 years with no medical disorder that could complicate the surgical phase or affect osseointegration (e.g., uncontrolled diabetes). For a hybrid screw-retained prosthesis to be fitted, the patient had to have a minimum bone height of 12 mm, good oral hygiene, and more than 15 mm of inter-arch space. Patients with recent extractions, intra-oral pathological conditions, including inflamed ridges or candida infection, or para-functional habits such as clenching were excluded.

Before enrolment, all patients were given complete information about the study and the treatment plan outlined in the clinical protocol, and all signed informed written consent. Each eligible patient received both treatments, randomly allocated to the right *versus* the left side of the arch. Hence, each patient provided both an intervention side (EWF) and a control side (CMF).

Interventions

Primary impressions (Cavex Alginate, Holland BV of Haarlem, Netherlands) diagnostic casts, facebow recording (Standard face bow, Bio Art, São Carlos, Brazil) and diagnostic bite were performed to obtain casts mounted on a semi-adjustable articulator (A7 plus Articulator, Bio-Art) and diagnostic setup of teeth. The denture base was removed from the mounted diagnostic cast, and the distance from the maxillary ridge to the occlusal plane of the lower teeth was measured. This distance was added to the mucosal thickness gained from bone sounding to give us the same restorative space. The distance had to be 15 mm or more to be indicated for hybrid prosthesis construction. The occlusal putty index was calculated on the buccal surface of the maxillary denture to act as a prosthetic guide in metal bar construction.

After diagnostic setup and intraoral try-in, a 1-mm-thick rigid, vacuum-formed, transparent acrylic resin was used to construct a radiographic stent for cone-bean computed tomography (CBCT) imaging. Using gutta-percha, the proposed implant positions were marked in the middle of the cingulum of the anterior teeth and the central fossa of the posterior teeth, and the radiographic stent was tried intraorally. Patients were instructed to wear the radiographic stent and bite on cotton rolls on both sides during CBCT scanning.

The width and height of bone were evaluated using BlueSky Plan Bio software (Blue Sky Bio, LLC, Chicago, IL, USA) at the marked positions of implants. For standardization of the results, the implants' widths and lengths were chosen in a manner that, as far as possible, both sides featured the same parameters.

Complete dentures were constructed for all patients following conventional procedures.

The rigid, vacuum-formed radiographic stent was transformed into a cast-based surgical guide by removing the gutta-percha and opening the prospective implant sites. Local anaesthesia was administered and a crestal incision was made from the first maxillary molar area on one side extending to the contralateral side, with two vertical releasing incisions buccally; a full-thickness mucoperiosteal flap was raised, exposing the underlying bone.

The surgical guide was inserted into the patient's mouth, supported by the operator's hands, and the pointed drill of the surgical implant kit used was inserted through it, indicating only the implant position. The drilling sequence was then completed using the manufacturer's instructions and surgical kit, taking care to ensure that on each side implants were parallel to each other using the guiding parallel pins.

Implants (Biomate Medical Devices Technology, Kaohsiung, Taiwan) of length 10 mm and diameter 4.1 mm were inserted at both central incisor, canine and second premolar positions. Incisions were closed with continuous suturing (Vicryl Undyed Braided & Coated Absorbable Suture, Ethicon, Bridgewater, NJ, USA) using the lock technique.

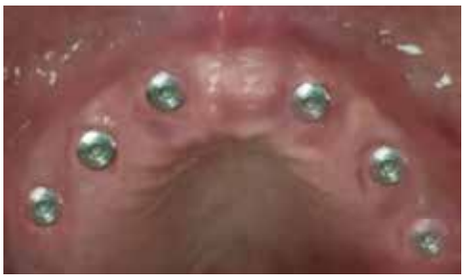

FIG. 1: *Implants with healing collars*

The patient's denture was relined to avoid pressure on the surgical side. All patients were instructed about oral hygiene measures, to follow a soft diet for four weeks after surgery, and to rinse with 0.2% chlorhexidine digluconate mouthwash twice daily for one week post-surgery.

After four months of osseointegration, a second stage of surgery was performed; the surgical guide was used to detect the position of the inserted implants to be exposed, and a healing collar was screwed to the implants (**FIG. 1**). After two weeks of soft tissue healing around the implants, prosthetic procedures were initiated.

Electric welded side (EWF)

Shaping abutments (Shaping screw-retained dental abutment, Biomate) were screwed onto the implants, and periapical radiographs were taken to ensure proper seating of the abutments; the welding point was a pre-existing or prepared flat surface area of the implant shaping abutment at the central incisor position on one side (right or left). A titanium bar (JDentalCare titanium welding wire, Modena, Italy), 1.5 mm in diameter, was shaped to fit the curves of the abutments.

At each welding site, shaping abutments were welded in the oral cavity using the ready-made curved titanium bar with the aid of the Syncrystallization Unit (JDentalCare syncrystallization welding unit). Welding is an electrical process shielded by an argon gas source (syncrystallization) with three stages: preparation, welding and cooling. The two electrodes of the welding pincers were placed on either side of the bar and the abutment, all of which were clean. The pieces to be welded were delicately brought into contact with the copper electrodes at the tip of the pincers, and then pressure was applied; firm and consistent pressure was applied to guarantee a flawless bond between the components to be welded. Full contact between the titanium bar and the welding abutment was maintained throughout the procedure. The parameters used for the electric welding were 25V, 50 HZ and 312J. An electrical current from a previously unloaded capacitor is passed to the copper electrodes of the welding pliers; the electrical current at the electrodes immediately elevates the temperature of the two titanium components to above their fusing point. The procedure raises the temperature of the titanium pieces' core to almost 1660 °C in just 2 to 5 ms. During this stage, a barely audible clicking sound can be heard. The titanium crystallizes at this point; hence, the bar and abutment must be kept under tight pressure. No filler metal was used during welding.

The procedure was carried out painlessly, and without causing any harm to the surrounding tissue, since no heat was passed to the peri-implant area due to the differing thermal conductivity of the copper electrodes and titanium components. The copper electrodes dissipate all of the heat produced. Finally, the prosthesis framework, constructed by welding the titanium bar to the implant abutments, was removed and finished in the lab.

Cast metal framework side (CMF)

Tray transfer copings (Open tray transfer coping, Biomate) were attached to the implants in the cast metal framework side. A periapical radiograph was taken to ensure complete transfer seating. Single-step open-tray unsplinted impressions were taken using additional silicone impression material (A-silicone Zhermack Hydroise Putty and Light body impression material, Badia Polesine, Italy), and the analogues mounted to the transfers. The primary cast was obtained by pouring extra-hard stone (Elite dental stone, Zhemack). After application of the tissue-mimicking material (Xilgum, Lascod, Sesto Fiorentino, Italy) to the impres-

sion, the transfers were splinted together with auto-polymerizing acrylic resin (Duralay, Inlay pattern resin, Worth, IL, USA); this was sectioned to be reassembled inside the patient's mouth to ensure the passive fit of the transfers onto the implants. A special acrylic tray with an opening corresponding to the transfer positions was constructed. The transfers were completely seated to the implants intraorally, and the separate sections of the splint were reattached using auto-polymerizing acrylic resin; then, a secondary impression was taken to obtain a master cast for use during framework construction.[8]

UCLA abutments (UCLA screw-retained dental abutment, Biomate) were fastened to the implant analogues. The framework wax pattern was made using the previously determined putty index to adjust the dimensions, and the wax pattern was cast in cobalt chromium and tried on the cast. Then, an intra-oral try-in was performed, and passivity was checked with a screw test.

Passive fit assessment and pick-up of the prosthesis

The fit between the implant abutments and their respective implant abutments of the prosthesis framework was inspected thoroughly to ensure that the framework fit passively and properly before being secured with a prosthetic abutment fixation screw. In the event of framework misfit, separation was performed using a disc, followed by intraoral splinting using auto-polymerizing acrylic resin and soldering. After framework soldering, another try-in was performed to ensure the framework's passive fit. **FIG. 2** shows the CMF and EWF tightened in their places.

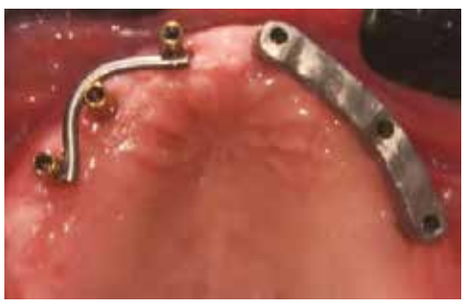

FIG. 2: *Example case in which the left side was rehabilitated using a randomly allocated EWF prosthesis and the right side with a CMF prosthesis*

The maxillary denture was modified to contain the frameworks, and completely seated intraorally. Occlusion was checked, and any needed adjustments were made. Then, the final pick-up of the frameworks into the denture was perfected. At the same time, the screw channel openings were closed using Teflon, and the patient was guided to bite in centric occlusion until the pick-up material (Luxa Pick-up material, Chemisch-Pharmazeutische, Hamburg, Germany) had completely set.

The prosthesis was then unscrewed, the palatal vault section and teeth distal to the upper second premolars removed, any white acrylic needed was added, finished and polished. The prosthesis was sectioned into two parts at the midline using a disc; then, the prosthesis was re-inserted, and pressure areas were marked with pressure-indicating paste and removed.

The screw channel openings were closed with Teflon and auto-polymerizing acrylic resin. Occlusion was checked, and occlusal adjustments were performed to obtain balanced occlusion. The cases were followed-up at the time of implant loading and then six months, nine months, and 12 months after prosthesis delivery.

Outcome measures

Primary outcome measures

1. Prosthesis failure: a planned prosthesis that could not be placed due to implant failure(s), loss of the prosthesis secondary to implant failure(s), or prosthesis replacement for any reason.
2. Implant failure: defined as implant mobility or removal of stable implants due to infection or increasing marginal bone loss. A broken implant was also considered a failure. The stability of each implant was determined by physically tightening the abutment screw with a wrench that delivers a torque of 30 Ncm. Failures related to spinning implants were noted.
3. Complications: any biological or prosthetic complications affecting the study implants and prostheses throughout the follow-up period were reported.

Secondary outcome measures

4. Peri-implant marginal bone level changes were assessed at the time of prosthesis loading (T0), and at 6 months (T1), 9 months (T2) and 12 months (T3) after prosthesis delivery. Long-cone standardized periapical digital radiographs were taken using a charge-coupled device (CCD) to assess peri-implant marginal bone loss. To standardize exposure parameters, each patient had additional silicon impression material mixed and applied between the maxillary screw-retained restoration and the mandibular denture near each implant. The patient was asked to bite down on the material to preserve the same sensor-implant distance; and cone-implant distance (40 cm) and patient position were fixed during subsequent digital radiographs on the day of prosthesis delivery with the help of a sensor position-holding system. This customized bite block was used in subsequent digital radiographs after it was set (customized jig). This adjustment resulted in standardized intraoral radiography, and thereby ensured reproducible radiographic analysis. At follow-up radiographic examination visits, the x-ray sensor was assembled to the customized jig in situ, and each customized jig was positioned in its place. The patient gently closed their mouth, and x-ray cones were positioned within the holder rings; the x-ray was taken, and digital images were generated for each implant in each patient. The procedure was performed for each patient on the day of prosthesis loading, and at 6, 9, and 12 months thereafter. The accompanying software (Digora Optime, Soredex, Tuusula, Finland) was used to trace the digital pictures. Bone resorption was calculated as the distance between the implant–abutment junction and the initial bone-to-implant contact (**FIG. 3**). The established implant length and width were used to adjust for magnification inaccuracies, adjusting image readings to their actual values. The bone resorption was averaged from the mesial and distal surfaces of each implant.
5. Prosthesis fit: the single-screw test was used to determine if the fit was "passive" or "not passive". The single-screw test measures the vertical gap formed between the prosthesis and the implant abutment, either in the middle or at the other end, following manual tightening of the retaining screw on the implant abutment of one end. To this end, a piece of dental floss was wrapped between the implant abutment and the prosthetic abutment of the framework. A prosthesis fixation screw was inserted into the most distal abutment and screwed down with finger pressure alone. If the gap between the framework abutment and implant abutment is less than the thickness of the floss, the floss will be grasped and prevented from slipping between two surfaces. Poor fit is indicated by a gap and rocking movements, observed when the verification jig is gently seated.

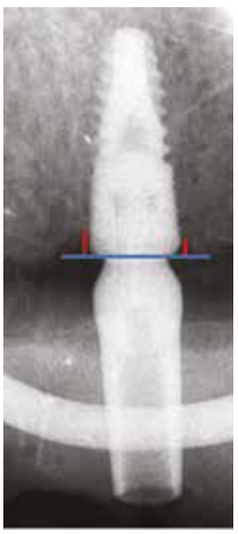

FIG. 3: *Measuring bone loss around implants. The red lines show gains or losses at the mesial and distal sites, while the blue line shows the baseline measurement at the implant neck*

Sample size

The sample size calculation was performed based on a power of 80% and an α value of 0.05, in line with a previous study[12], in which the mean difference between two groups regarding bone height change measurements was 2.07±0.46 mm. The sample size was calculated to be at least 10 cases. We then increased the number of anticipated missing data by 20% to compensate for dropouts, 12 per group, and 12 patients. Twelve patients who attended the prosthodontics Cairo University Faculty of Dentistry Department Outpatient Clinic, Egypt, were enrolled in the study.

Randomization and allocation concealment

After implant placement, at the second stage of surgery, each eligible patient's right and left sides of the maxilla were randomly assigned, using a computer-generated system, to receive EWF and CWF, respectively. Opaque envelopes were sealed, according to a computer-genera-

ted list, by an investigator who was not involved in patient management. Each envelope contained a card with a number that determined which intervention should be performed on the right side of the arch, and the left side was assigned to the other intervention.

Blinding

It was impossible to blind either the dentist who made the prostheses or the assessor who assessed bone level changes. However, the outcome assessor for complications was not involved in patient management and was blinded to the participant's group.

Statistical methods

Statistical analysis was performed using SPSS 20 (Statistical Package for Social Science, IBM, USA). All qualitative data are presented as frequency and percentages. All comparisons were performed using the McNemar test. Comparisons between the two groups were performed using a paired t-test.

RESULTS

Twelve patients (8 males and 4 females), of mean age 63±13.9 years old, were included in the study. Of the 50 patients recruited and assessed between October 2020 and December 2021, 38 were excluded as they declined to participate or did not meet the inclusion criteria. Twelve patients (24 sides) were enrolled and randomly allocated to EWF or CMF (12 sides to each group). All patients attended the 12-month follow-up. All data from the 12 patients (24 sides), were analysed.

Outcomes and estimation

No prosthesis or implant failure occurred. There were five complications recorded in the CMF group, and two in the EWF group. However, there was no statistically significant difference in complication rate between the two groups (risk difference = -0.25, CI 95% -0.60 to 0.10, P = 0.16.) Concerning biological complications, two implants in the CMF group exhibited peri-implant mucositis at 6 and 9 months post-implantation. Similarly, one implant in the EWF group showed peri-implant mucositis at 12 months post-implantation. Curettage and 0.2% chlorhexidine mouthwash were used to treat this problem.

Regarding prosthetic complications, one case of CMF implant-supported prostheses screw loosening was recorded at six months and another at 12 months. In addition, there was one

TABLE 1 COMPARISON OF MEAN DIFFERENCES AND STANDARD DEVIATIONS OF PERI-IMPLANT BONE HEIGHT CHANGES IN BOTH GROUPS AT DIFFERENT TIME-POINTS EXPRESSED IN MM

	CMF		EWF		MD (95% CI)	P value
	Mean	SD	Mean	SD		
Baseline	0.03	0.016	0.04	0.02	0.01 [-0.04, 0.024]	0.56
Baseline-6 months	-0.40	0.11	-0.08	0.13	-0.32 [-0.48, -0.07]	0.019*
Baseline-9 months	-0.73	0.18	-0.22	0.24	-0.51 [-0.88, -0.02]	0.04*
Baseline-12 months	-0.97	0.15	-0.43	0.28	-0.54 [-1.03, -0.31]	0.005*

CI: Confidence interval, MD: mean difference, SD: standard deviation

case of occlusal discrepancies recorded at two weeks, and there was a prosthetic tooth fracture during the six-month follow-up period in the EWF group.

Both groups showed comparable bone levels at baseline, specifically, 0.03±0.016 mm, and 0.04±0.02 mm for CMF and EWF, respectively (P = 0.56). Comparing CMF and EWF groups (**TABLE 1**) in terms of bone height changes between the different assessment intervals revealed a significant difference at 6 months (-0.32 mm [-0.48, -0.07], P = 0.019), 9 months (-0.51 mm [-0.88, -0.02], P = 0.04), and 12 months (-0.54 mm [-1.03, -0.31], P = 0.005), with the EWF group displaying significantly less bone loss than the CMF group.

Furthermore, all 12 EWF prostheses were passive, while eight CMF (67.3%) prostheses were passive and four were not (33.3%). This difference was also statistically significant (risk difference -0.33, CI 95% -0.05 to -0.61, P = 0.02).

DISCUSSION

The above results indicate that EWF results in better prosthesis fit and less bone loss than CMF.

Split-mouth randomized controlled trials (RCTs) randomly assign experimental and control treatments to distinct parts of the oral cavity (teeth, surfaces, arches, quadrants). Compared to parallel-arm RCTs, split-mouth RCTs offer the benefit of removing much of the heterogeneity of outcomes across patients from the intervention effect estimate, potentially increasing their statistical power[13].

A lack of passivity of the definitive prosthesis can cause internal stresses in the framework of the prosthesis, the implants, and the bone surrounding the implant, resulting in mechanical complications such as screw loosening, screw fracture or framework fracture, as well as monolithic prosthesis fractures[14]. Screw loosening is a significant issue with screw-retained implant restorations, potentially leading to mechanical and biological complications, including screw fracture under load[15]. It has been reported that screw loosening is relatively common in CMF prostheses as a result of the many clinical and laboratory procedures involved in cast framework construction, including impression-taking, master cast construction, wax pattern construction, casting, prosthesis try-in and prosthesis delivery, which could all affect the passivity of the final prosthesis. Lack of passivity may lead to mechanical complications such as screw loosening and even screw fractures[16]. In this study, screw loosening was recorded in two cases of CMF and none for EWF.

A prospective cohort study reported data on the maintenance outcomes of screw-retained implant-supported full-arch hybrid prostheses in the edentulous maxillary arch. During professional recall visits, fractured denture teeth were the most common complication. The status of the opposing dentition and the cantilever length did not affect the risk[17].

Prosthetic complications can be divided into early complications, during the first year of prosthetic loading, and delayed complications, after the first year, and another study[18] found that fixed maxillary prostheses required professional maintenance over two years. The likelihood of a complication occurring in the first year ranged from 60% to 70%. In contrast, the results of this study revealed fewer prosthetic complications with both frameworks, which could be explained by the methodology, which included the use of EWF with low misfit frequency. In the CMF group, on the other hand, every effort was made to achieve good results, including splinting the impression coping to reach accepted passivity, significantly influencing prosthesis maintenance[19]. Moreover, in ill-fitting CMFs, separation was performed using a disc, followed by intraoral splinting using auto-polymerizing acrylic resin and soldering. After framework soldering, another try-in was performed to ensure the framework's passive fit. This may help explain why difference in prosthetic maintenan-

ce between the two interventions was insignificant at all time points. This outcome was likely also influenced by the small sample size, short-term follow-up and the proper planning of tooth positions, which helped properly align the teeth[20,21]. In any event, a study by Örtorp and Jemt[22] showed no difference between laser-welded framework and CMF after 15 years of function.

Despite the breakage of resin veneers being a well-known issue in implant dentistry, in this study, its insignificance could be due to the short follow-up period. In a 15-year follow-up study, the most frequent problems during follow-up were soft tissue inflammation and fractures of resin veneer[22].

The great passivity of the frameworks, specially EWF, could explain the minor prosthetic complications. Furthermore, the possibility of intraoral welding of metal prosthodontic components without risk, soft tissue damage or discomfort to the patient is advantageous. Welding eliminates the costly and time-consuming process of impression-taking, with its inherent inaccuracies[14]. In this study, the abutments were tightened, their proper seating verified radiographically, and the titanium framework welded intraorally without any impressions[23].

It has been mentioned that among the most frequent major issues with hybrid prostheses is substantial wear of the prosthetic material (5.85 percent/year). In comparison, the most frequent minor event is the loss of screw access hole material (5.18 percent/year)[24]. This finding is in line with the 15% average abutment screw loosening reported in a study covering the first decade of single implant therapy[25].

Since the late 1990s, a significant reduction in mechanical complications has been reported, as new prosthetic designs, materials, and better torque control have been introduced[26,27]. In the overall amount of prosthesis issues, the opposing dentition considerably impacts prosthetic material wear, access hole material loss and framework fracture[24]. In this study, the opposing arch was restored with a conventional complete denture in all cases, taking care to frequently reline the lower denture with a soft liner. This precaution mitigates the effect of different dentition on the opposing implant-supported prosthesis.

A mean change in bone height of 1 mm after 12 months of loading was detected in the CMF group, which is considered a "physiological" amount of bone loss around implants. Indeed, according to the literature, the amount of bone lost during the first year of function is 1 mm[28]. However, bone loss may be affected by different framework types; when comparing titanium frameworks to gold frameworks, it has been observed that titanium frameworks are associated with lower mean bone loss[29]. Furthermore, it has been reported that the laser-welded titanium frameworks display superior passive fit, thereby reducing the stresses on the implant–bone interface and resulting in less peri-implant bone resorption[30]. Moreover, other authors have demonstrated that cast metal frameworks induce more bone loss than carbon-fibre and laser-welded titanium[31-33].

In our study, the comparison between the two frameworks in terms of bone height changes at different time-points revealed a significant difference in favour of the electrically welded group. This may be a result of the inaccuracies that can emerge during the impression-taking and lab manufacturing procedures required for conventional casted framework techniques. These sources of error are eliminated by the intraoral welding technique, which also reduces the cost and provides rigid splinting for an immediate prosthesis[34].

In terms of the significance of passively fitted prostheses, it was reported in a study evaluating the pressures induced by a non-passively fitting implant-supported prosthesis that bone adaptation can result in several micrometres of implant site displacement. It has been accepted that intra-oral welding provides fast and rigid splinting of the implants, resulting in a passive-fit prosthesis[35].

In addition, the increase in bone loss in the CMF group could be caused by misfit, which may result in bacterial colonization and peri-implant tissue inflammation, resulting in biological and mechanical complications[36].

The accepted amount of bone change in both groups could be caused by the use of the shortened dental arch concept, which eliminates the cantilever effect, as well as providing even distribution of loads, leading to a decrease in the amount of stress transmitted to the peri-implant tissues[37,38].

From a practical point of view, the operator found that welding was much simpler and more time-efficient than casting. Indeed, the welding process takes only a few seconds, whereas cast frameworks require multiple impressions and multiple steps in the lab, increasing chair-side and manufacturing time, as well as the time needed for final prosthesis insertion. The welding approach decreased the framework construction cost by decreasing chair-side time and eliminating the need for multiple impressions and associated lab costs.

The study has significant limitations, namely the small sample size and the fact that, except for complication rates, all outcome measures were recorded by investigators who treated the patients and were aware of patient allocation. Moreover, the cases were only followed-up for 12 months.

Nonetheless, both interventions were studied under real-world clinical conditions, and the patient inclusion criteria were broad, so the current trial findings may be extrapolated to patients with comparable features.

CONCLUSIONS

Within the limitations of this study, it can be concluded that electric welding of implant-supported frameworks may be considered a comparable treatment option to the conventional cast framework in terms of complication rate, but results in better prosthesis fit and 0.5 mm less peri-implant bone loss up to one year after loading.

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