
The aim of this article is to propose a simplified digital protocol for the treatment of the fully edentulous patient, using an immediate implant and immediate loading protocol to deliver a polymethyl methacrylate metal-reinforced hybrid prosthesis. Ten consecutive patients were treated with this approach. At the end of 1 year, there was an implant survival rate of 97.8% and a prosthetic success rate of 100%. Based on the responses to the quality of life questionnaire, patients had a high acceptance rate for this treatment protocol. Within the limits of this case series, the proposed simplified digital protocol could be utilized for reconstruction in the fully edentulous patient and for delivering an implant-supported prosthesis immediately after implant placement. Int J Periodontics Restorative Dent 2021;41:33–40. doi: 10.11607/prd.4822

Oral reconstruction with endosseous implants and immediate loading in cases with fully edentulous dentition is a challenging and evolving topic in the field of dentistry. When there is a loss of all aesthetic and functional parameters due to advanced periodontal disease, such as extreme wear or loss of all the teeth, clinicians must first reestablish the proper vertical dimension and intermaxillary relationship before planning implant surgery.

The fundamental rules (such as creating good esthetics, function, and phonetics) for the rehabilitation of fully or partially edentulous patients do not differ when the clinician is planning for a removable complete denture or an implant-supported prosthesis. In modern implant dentistry, the clinician gathers the information needed to formulate a diagnosis that, in turn, allows them to propose the most appropriate surgical and prosthetic solution for each patient. This collaborative solution between the prosthetic and implant teams must begin in the diagnostic phase, which is the most important phase for successful outcomes, in order to guide the therapeutic options in the correct direction and to addressing the patient’s expectations. The objective examination of a patient who is a candidate for implant therapy is fundamental to the diagnosis and...
treatment-planning process, and it can be divided into two evaluation phases (extraoral and intraoral) in which the clinician must evaluate esthetic, functional, and phonetic parameters. If these parameters are already correct in the existing prosthesis or dentition, then the surgical plan can start. If not, they should be reestablished.

In the classical approach, an accurate 3D evaluation of the available bone structure is done via radiographic examination. For precise estimation of available bone, implant position, angulation, and length, a computed tomography or CBCT scan with a radiographic template is highly recommended. In a fully edentulous patient, the best technique is to perform a CBCT scan with fiduciary markers, allowing the assessment of the relationship between the two arches, and the position of the future prosthetic teeth in respect to the residual bone crest on both the horizontal and vertical planes. If the full denture presents incorrect parameters, a CBCT with fiduciary markers may not give the correct arch position or the accurate relationship between the bone and the future prosthesis.

The aims of the present study were: (1) to propose a three-step, diagnostic, restoration-driven simplified digital protocol (SDP) that utilizes thermoplastic templates of different sizes with radiotransparent bites and radiopaque markers that allow the clinician to easily evaluate esthetic, functional, and phonetic parameters in the first consultation before CBCT scanning; and (2) to evaluate implant survival rate, prosthesis success, results of the quality of life questionnaires, and efficiency of this restoration-driven SDP.

**Materials and Methods**

This prospective clinical case series included 10 patients who were treated at two centers (6 patients at IRCCS Galeazzi Orthopedic Institute and 4 patients at Ospedale Maggiore Policlínico). A written informed consent form was obtained from all patients, and the study protocol was approved by the institutional review board of the IRCCS Galeazzi Orthopedic Institute. The patients were consecutively treated between May 2018 and May 2019. Patients who were fully edentulous or transitional (needing to remove all teeth) and who required a full-mouth rehabilitation were included in the study. Patients were excluded from the study if they were heavy smokers (≥ 10 cigarettes/day), had American Society of Anesthesiologists Classification 3, and/or were unable to perform oral hygiene at home.

Complete medical and dental histories were collected to ensure that each patient was a candidate for the planned surgical treatment. A professional oral hygiene session was given to each partially edentulous patient within a week before surgery and was repeated 1 hour before surgery. Before implant surgery, all patients were prescribed pre- and postoperative antibiotics: 2 g Augmentin (GlaxoSmithKline) 1 hour before the surgery and 1 g every 12 hours for 5 days. For patients with a penicillin allergy, 500 mg of Klacid (Abbott) was used instead.

The SDP treatment protocol consists of three steps:

**Step One: Diagnostic Planning**

The first step had clinicians establish the correct arch relationship using thermoplastic templates (Evoguide Evobite Tray, 3DIEMME). Radiopaque silicon is used to register the correct arch relationship and occlusion. For fully edentulous patients, the templates have the maxillary anterior teeth already present, which can be modified based upon their esthetic, functional, and phonetic parameters for the selected length and dimensions of the teeth (Fig 1). These radiopaque markers can also be used as radiologic stent markers in the CBCT examinations in steps two and three.

**Step Two: Try-in Visit**

A 3D-printed denture that incorporates all data obtained from the adaptation of the thermoplastic template and the information relevant to the prosthetic (eg, vertical height, occlusion, and phonetics; Fig 2) was used to establish the proper occlusal relationship. At this appointment, the clinician will double-check all of the parameters gathered during step one and can make final adjustments before surgery if needed. After, the surgical prosthetic plan was finalized by the use of a dedicated software (RealGUIDE 5.0, 3DIEMME) or any other planning software (Figs 3 and 4).
Step Three: Surgical Prosthetic Phase

At this appointment, implants were inserted following 3D-generated prosthetically based implant surgical stents. A full-thickness flap and regenerative procedures were carried out if needed. Intermediate abutments and prosthetic cylinders were then placed directly following implant placement, and a rubber dam was situated (Fig 5). Thereafter, cylinders were connected to the polymethyl methacrylate metal-reinforced hybrid prosthesis using a self-adhesive resin cement (RelyX Unicem 2 Automix, 3M ESPE; Fig 6).

The hybrid prosthesis was then polished and screwed in place (Fig 7) and clinically and radiologically followed up for 20 months (Fig 8). Each patient was then scheduled to receive professional maintenance every 4 months. A postsurgical quality of life questionnaire was obtained from each patient after 1 week, and a prosthetic quality of life questionnaire was collected at the 1-month follow-up appointment to assess the treatment outcomes and the success of the treatment SDP.

Results

A total of 46 implants were placed (23 in the mandible, 23 in the maxilla). The patient demographic details are presented in Table 1, and the surgical and prosthetic details are given in Table 2. The distribution of the implants is shown in Fig 9.

The implant survival rate was 97.8% at the 20-month follow-up
and intraoral evaluation, are needed prior to performing implant surgery. In order to accomplish these goals, the use of tools, devices, and planning software that could provide proper information about the final prosthetic restoration is a mandatory step, both in a traditional approach (manual or digital-based) or in this three-step SDP.

This SDP simplifies the procedure and has a high patient acceptance and satisfaction. The use of thermoplastic templates and a 3D-printed try-in can provide the clinician and dental laboratory with all of the needed information before implant planning and allow the production of a polymethyl methacrylate metal-reinforced hybrid prosthesis before surgery. Compared to a digital workflow, the current protocol provides the clinician with a physical template that is more realistic than a virtual setup in clinical practice. Since the restorative dentist/prosthodontist has an opportunity to check the functional and esthetic parameters in a clinical

(Fig 8). All immediate prostheses were delivered as planned in the presurgical phase, and the prosthetic survival rate was 100%. The results obtained from the questionnaires are shown in Fig 10. Briefly, all patients were satisfied with the surgical treatment and their prostheses, and all patients were able to chew properly and speak without difficulty.

There were no complications during the surgeries, and all prostheses were delivered as planned.

One patient reported pain and swelling 3 weeks after surgery in a specific area, and this issue was solved by removing the implant placed.

**Discussion**

Oral rehabilitation of edentulous patients is a complex and challenging procedure. Correct jaw relationship, such as vertical dimension, centric relationship, facial support,

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Fig 8 (a) Clinical intraoral view and (b) orthopantomography and (c) periapical radiographs of the prosthesis at the 20-month follow-up.

Table 1  Patient Demographics

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Center no.</th>
<th>Age, y</th>
<th>Gender</th>
<th>ASA class</th>
<th>Pathology/ chronic condition</th>
<th>Medication</th>
<th>Smoker</th>
<th>Opposite dentition</th>
<th>Parafunction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>66</td>
<td>F</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>No</td>
<td>Overdenture</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>59</td>
<td>F</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>No</td>
<td>Fixed</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>69</td>
<td>F</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>No</td>
<td>Overdenture</td>
<td>–</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>78</td>
<td>M</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>No</td>
<td>Natural</td>
<td>–</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>59</td>
<td>F</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>Yes</td>
<td>Natural</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>75</td>
<td>M</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>Yes</td>
<td>Total</td>
<td>–</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>82</td>
<td>M</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>No</td>
<td>Natural</td>
<td>–</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>62</td>
<td>M</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>Yes</td>
<td>Partial denture</td>
<td>–</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>74</td>
<td>F</td>
<td>2</td>
<td>Hypertension, hypothyroid</td>
<td>Eutirox, lercanidipine</td>
<td>No</td>
<td>Partial denture</td>
<td>–</td>
</tr>
<tr>
<td>10</td>
<td>2</td>
<td>87</td>
<td>F</td>
<td>2</td>
<td>Hypertension</td>
<td>Losazid</td>
<td>No</td>
<td>Total</td>
<td>–</td>
</tr>
</tbody>
</table>

ASA = American Society of Anesthesiologists Classification; F = female; M = male.
Center 1 was the IRCCS Ospedale Maggione Policlinico in Milan, Italy. Center 2 was the IRCCS Orthopedic Institute Galeazzi in Milan, Italy.
<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Reason for teeth loss</th>
<th>Flap type</th>
<th>Surgical stent support</th>
<th>Prosthesis type</th>
<th>Complications</th>
<th>Implant brand and dimension</th>
<th>Implant no. (position)</th>
<th>Graft material</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>–</td>
<td>FS</td>
<td>M</td>
<td>Screwed</td>
<td>–</td>
<td>FIXO*: 3.5 × 11.5, 17 (3) and 30 (1)</td>
<td>4 (SP)</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>Periodontal-endodontic infection</td>
<td>FS</td>
<td>M</td>
<td>Screwed</td>
<td>–</td>
<td>FIXO*: 3.5 × 11.5, 0 (1); 3.5 × 13, 0 (1) and 30 (2)</td>
<td>4 (C)</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>–</td>
<td>FT</td>
<td>M</td>
<td>Screwed</td>
<td>–</td>
<td>Progressive-Line*: 3.8 × 11 (2); 3.8 × 13 (4)</td>
<td>6 (SC)</td>
<td>Bio-Oss + Bio-Gide</td>
</tr>
<tr>
<td>4</td>
<td>–</td>
<td>FS</td>
<td>M</td>
<td>Screwed</td>
<td>–</td>
<td>FIXO*: 4 × 15, 30 (2); 3.5 × 11.5, 17 (2)</td>
<td>4 (C)</td>
<td>Bio-Oss</td>
</tr>
<tr>
<td>5</td>
<td>Periodontal disease</td>
<td>FT</td>
<td>B</td>
<td>Screwed</td>
<td>–</td>
<td>Tapered Internal*: 3.4 × 15, 3 (3); 3.4 × 12, 3 (1); Tapered Plus*: 3.8 × 15, 3 (1)</td>
<td>5 (SC)</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>Periodontal disease</td>
<td>FT</td>
<td>B</td>
<td>Screwed</td>
<td>–</td>
<td>Tapered Internal*: 3.8 × 12, 3.5 (2); 3.8 × 15, 3.5 (2)</td>
<td>4 (SC)</td>
<td>–</td>
</tr>
<tr>
<td>7</td>
<td>Periodontal disease</td>
<td>FT</td>
<td>B</td>
<td>Screwed</td>
<td>–</td>
<td>Tapered Short*: 4.2 × 10.5, 3.5 (2); 4.6 × 7.5, 3.5 (2); 4.6 × 9, 3.5 (2); 4.6 × 10.5, 3.5 (1)</td>
<td>7 (C)</td>
<td>Gen-Os Mix</td>
</tr>
<tr>
<td>8</td>
<td>Periodontal disease</td>
<td>FT</td>
<td>B</td>
<td>Screwed</td>
<td>–</td>
<td>Tapered Internal*: 3.4 × 15, 3 (4)</td>
<td>4 (SC)</td>
<td>Gen-Os Mix + L-PRF</td>
</tr>
<tr>
<td>9</td>
<td>Periodontal disease</td>
<td>FT</td>
<td>M</td>
<td>Screwed</td>
<td>–</td>
<td>Tapered Implant*: 4.2 × 15, 3.5 (2); 4.6 × 15, 3.5 (1)</td>
<td>4 (C)</td>
<td>L-PRF</td>
</tr>
<tr>
<td>10</td>
<td>Periodontal disease</td>
<td>FT</td>
<td>B</td>
<td>Screwed</td>
<td>–</td>
<td>Tapered Internal*: 3.8 × 12, 3.5 (3); 4.2 × 12, 3.5 (1)</td>
<td>4 (SC)</td>
<td>L-PRF</td>
</tr>
</tbody>
</table>

FS = flapless; FT = full-thickness; M = mucosal; B = bone; SP = supracrestal; SC = subscrestal; C = crestal; L-PRF = leukocyte- and platelet-rich fibrin.

Implant brand and dimension information: size in mm, degrees (n).

*aOxy Implant, Biomec.
*bCamlog.
*cBioHorizons.
*dGeistlich.
*eOsteoBiol.
*fIntraSpin System, Intra-Lock International.
Fig 9  Distribution of the implants in the (a) maxilla and (b) mandible.

1. Do you feel pain in the treated site?
2. Did you have to take the prescribed painkillers?
3. Do you feel swelling in the treated site or around it?
4. Is there any bruising on the cheek?
5. Is your sleep affected?
6. Is your chewing altered?
7. Is your speaking altered?
8. Is there bleeding in the treated site?
9. Did you feel nauseous?
10. Did you have taste alteration?

Fig 10  Results of (a) the post surgery quality of life questionnaire at the 7-day follow-up and (b) the posts prosthetic quality of life questionnaire at the 1-month follow-up. 0 = maximum satisfaction; 10 = maximum dissatisfaction; 0–3 = fully satisfied; 4–6 = moderately satisfied; 7–10 = poorly satisfied.

1. How do you rate the prosthesis esthetic result in general?
2. How do you rate the color of your new teeth?
3. How do you rate the shape of your new teeth?
4. How do you rate the size of your new teeth?
5. How do you rate the appearance of the gums around the new teeth?
6. How do you rate your chewing ability with the new prosthesis?
7. How do you rate your speech with the new prosthesis?
8. How do you rate your home-care hygiene performance around your new prosthesis?
9. How closely does the result meet your expectations?
setting during the first and second visits, this in turn will minimize the issues and error related to current digital planning (eg, image deviation and distortion, print error, etc). This allows the clinician to produce a well-fitting implant-supported prosthesis before and after implant placement and provides patient satisfaction. This is further confirmed by the outcomes from the quality of life questionnaire obtained from the patients, which indicated the overall high success rate and high acceptance of the treatment SDP.

Conclusions

This protocol allowed simplification of the procedures for the surgical/prosthetic team while maintaining high implant and prosthetic success rates with high patient satisfaction.

All the prostheses were delivered as planned, confirming that the SDP could be a viable option for the rehabilitation of fully edentulous or transitional patients. This protocol needs further validation; however, the preliminary clinical results are very promising in terms of enhanced efficiency of the overall procedure.

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Author contributions: Conception and design of the analysis: T.T., M.D.F., and H.L.W.

References