Impression of multiple implants using photogrammetry: Description of technique and case presentation

By David Peñarrocha-Oltra, Raquel Torrado, Marcus Fuentes, Le-ricia Bagán, Beatriz Giménez, María Peñarrocha

Abstract

Aim: To describe a technique of registering the positions of multiple implants using a system based on photogrammetry and to present a case in which a prosthetic treatment was performed using this technique.

Study Design: Three Eurotechni-kaf® dental implants were placed to rehabilitate a 55-year-old male patient with right posterior maxillary edentulism. Three months later, the positions of the implants were registered using a photogrammetry-based system (PICabutment®). After processing patient and implant data, special abutments (PICabutment®) were screwed onto each implant. The PICcamera® was then used to capture images of the implant positions, automatically taking 150 images in less than 60 seconds. From this information, a 3D model of the implant positions was built, automatically describing the relative positions - angles and distances – between implants. Information regarding the soft tissues was obtained from an alginate impression to be cast in plaster and scanned. A C-Co structure was obtained using a photogrammetry-based method. The fit was verified in the patient's mouth using the Sheffield test and the screw resistance test.

Results and Conclusions:

Twelve months after loading, peri-implant tissues were healthy and no marginal bone loss was observed.

The clinical application of this new system using photogrammetry to acquire the relative positions of multiple dental implants facilitated the rehabilitation of a patient with posterior maxillary edentulism by means of a prosthesis with optimal fit. The prosthetic process was accurate, fast, simple to apply and comfortable for the patient.

Key words: Dental implants, photogrammetry, dental impression technique, CAD/CAM.

Introduction

Dental implants are one of the most widely used therapies for the rehabilitation of partially or completely edentulous patients. It is scientifically proven that achieving proper osseous fit of the implant-supported prosthesis improves the long-term prognosis of this therapy (1-3). The classical system for fabricating implant-supported prosthesis requires a record of the positions of multiple implants, and after placement of the implant analogues, subsequent casting in plaster to make impression transfers. In order to achieve an adequate passive fit of the prosthesis, it is necessary to obtain a cast record of the three-dimensional position of the implants (4). Conventional impression techniques use abutments that, screwed onto the implants' prosthetic platforms and encompassed by setting material, should register and transfer the spatial position of the implant. These methods involve time-consuming clinical work and the use of impression materials and techniques that often fail to achieve a perfectly accurate master cast. Moreover, these techniques are generally unpleasing for the patient (7,8). The literature reflects an increasing application of digital techniques at different stages of dental implant therapy (9). At the stage when impressions are taken, intraoral scanners are being introduced into clinical practice. The technique avoids the need for registering implant positions with impression materials and plaster model board and so avoids the slight dimensional loss that these materials can cause, ensuring expression when it comes to reproducing intraoral dimensions (7,10,11). These instruments are a promising alternative for obtaining directly intraoral impressions in a fast and comfortable way for the patient. However, they are not indicated for implant rehabilitations requiring more than 5-4 pieces.

Photogrammetry is a novel op- tion for reliable, direct intraoral registration of the positions of multiple implants in a tech- nique for determining the geometrical properties of objects and their spatial arrangement from photographic images. Its most important feature is the precision with which it can measure objects without direct contact.

Photogrammetry is useful in many sciences and fields. It has been applied mainly to topogra- phy, but there are many non-topo- graphic applications, including different areas of medicine such as radiology (to improve accu- racy), surgery (neurosurgery, plastic surgery, sinus surgery) or rehabilitation (13,14).

This technique has been used to study the shapes and positions of teeth, dental arches and maxillary and mandibular bones. In orthodontics, it allows the three-dimensional analysis of the variations of the palate while performing rapid palatal expansion techniques and evaluating the achieved dental movement (15-18). Re- cently, its application in dental implant surgery planning has also been reported (19).

In the field of implant dentistry, it has been used to check the ac- curacy of other impression tech- niques, by analyzing the differ- ences between digital models obtained using different techniques and materials (20). As long ago as 1999, Jent and Black (21) pro- posed photogrammetry as an alternative to conventional im- pression techniques, stating that then no development of this applica- tion has been reported. The most important quality of this technology - measurement accuracy - is the key to success in implant impressions. Therefore, its application may be a very useful technique that will improve dental implant therapy.

The aim of this report is to de- scribe this technique applied to record the position of multiple dental implants using a system based on photogrammetry. A case is presented in which a prosthetic treatment was per- formed successfully using this technique.

PICcamera®

The PICcamera® (PICdental, Madrid, Spain) is a stereocam- eras that record implant posi- tions in the mouth by means of photogrammetry. It comprises two CCD cameras especially de- signed for implant positions with impression use, which accurately determine the position of the implants by means of the identification of abutments screwed on implants with unique individual coding (PICabutment®, PICdental). The camera has an infrared flash that constantly illuminates the scanned object while elimi- nating the shadows that occur with ambient light. The PIC- camera® normally needs to capture 50 three-dimensional photographs for every two PICabutments®. To this, it automatically takes ten extraoral pictures per sec- ond with an error of less than 10 micrometers in angles and distances between implants are interleaved and treated as a unit. System software calculates av- erage angles and distances between implants from these photographs, obtaining an ac- curate relative position of each implant, thus allowing the identification of the PICfile®. This information was automatically compiled into a vector PICfile® (PIC-dental).

The healing abutments were placed and an alginate im- pression was taken and cast in plaster. The plaster model was scanned with a 3D scanner in open STL format to obtain infor- mation regarding the patient's soft tissues (1). This infor- mation was then introduced in the CAD software together with the PICfile®. The PICfile® and the digitized plaster model were aligned with the Exocad® software (Exocad GmbH, Darmstadt, Germany) using three-point registration and subsequently improved alignment by Best-fit® (Fig. 1). This process transferred the relative position between im- plants to the digital model which provided the shape of the soft tis- sues, thus leaving the interfaces of the future prosthesis in rela- tion to the patient's gingiva (Fig. 1).

A model of the antagonist arch was also scanned and centered in the CAD software to provide occlusal re- ferences, and the prosthetic structure was designed using Exocad® (Exocad, GmbH) in STL format (Fig. 2). The design was sent to be machined in chrome-cobalt (Cr-Co) by a five- axis milling machine (Fig. 2).

To build a working model, the digital model was processed providing the specific geom- etries of the implant connections (Fig. 3) and it was manufactured by means of stereolithography using a 3D printer (Objet 2500 Eden, Israel). The model was processed in a manner that al- lowed the addition of false gum for further work in the labora- tory (Fig. 4).

Once the internal structure of the implant-supported fixed par- tial denture had been fabricated, its passive fit was checked in the patient's mouth. The Sheffield and one-screw tests were used: a distal screw was placed in the screw at 14 in this case - and a periapical radiograph was ob- tained to check the correct prosthetic settlement on the other two implant connections (Fig. 2). The screw resistance tech- nique was used as a subjective complementary test of the pas- sive fit. Distal screws (14 and 17) were screwed with a torque of 10 Ncm and then a medial screw was introduced verifying that the tactile sensation was soft and presented no resistance to screwing. After these verifica- tions, the Cr-Co structure was sent to the laboratory to have the ceramic loaded.

The prosthesis, once finished, was screwed onto the implants (Fig. 5), with 25 Ncm torque. Occlusal adjustments were performed and the correct set- tlement on the implant con- nections was verified with a radiograph (Fig. 3). A follow-up plan was established and twelve


Fig. 1. A) View at three months after the placement of three implants in the right maxillary posterior region with dental implants. B) Record of the implant positions using the PICcamera®. C) Digitized plaster model; D) Alignment by means of Best-fit® from the PICfile® vector file and digi- tized plaster model; E) Relative interface positions of the future prosthesis in relation to the gums.

Fig. 2. A) Upper and lower plaster models and design of the prosthetic structure; B) Machined metal structure in Cr-Co; C) Digital working model; D) Stereolithography working model with false gums; E) Check- ing the metal structure in the mouth; F) Periapical radiograph during the Sheffield test.
months after loading, the peri-
implant tissues were healthy and no peri-implant marginal bone loss was observed (Fig. 5). Discussion The provision of ten-
sition forces between implants and the prosthesis structures they support is a re-
quirement for medium- and long-term success of implant-
supported rehabilitations. This situation is achievable by carrying out a prosthodontic treatment with good passive fit. Prosthetic therapy, on all clinical and laboratory proce-
dures involved in fabricating the prosthesis, is performed precisely and accurately, keep-
ing the margins of error and imprecision within the process to a minimum (1,22).
In vitro studies have shown that discrepancies in the super-
structure will be the cause of stress on the implant-supported prosthesis and subsequent fail-
ure. As long ago as 1986, Rubino described mechanical failures which he associated with labo-
ratory work carried out using impres-
sing techniques. Jent et al. (8) and Rubino et al. all agree on the importance of the fit be-
tween prosthesis and abutment is a key parameter for avoiding overload of the abutment screw which leads to prosthesis failure. For this reason, the taking of im-
pressions for obtaining structures with a good passive fit. There is some controversy in the literature as to which impression technique is the most reliable. Recent research with conven-
tional techniques is impossible to achieve a perfect passive fit. A recent review of the precision of im-
pression techniques, found that 55% of the tests performed con-
sidered the open try technique to be the most precise, 15% the repeated open try technique and 30% no statistically signif-
ificant differences between the 3 techniques. The number of implants in relation to precision, with three or more implants there did not appear to be any difference between techniques, with four or more the open try tech-
nique was found to be the most reliable (6). The greater accu-
racv of the open try technique is confirmed by Cehreli et al. (23) who studied the aver-
age discrepancy with each tray size of the impression technique, this being 0.169 μm for repositioning cop-
ings and 0.57 μm for open try coping.
The concept of photogrammetry con-
ists of measuring what is visible with light, in other words, obtaining reliable metric in-
fomation from photographs. The photogrammetry method extends the two-dimensional information provided by pho-
tographs into three dimensions by scanning various cameras, the shape of each of the photographic ob-
jects captured by the camera in space are reconstructed in relation to an external system of reference points. These are the necessary calculations for reconstruction, special cameras are required that are able to identify this sys-
tem of reference points. Photogrammetry has been ap-
plied in various areas of medi-
cine (15,14) and dentistry (15-
19). In implant dentistry, it has
been used in vitro research to test the reliability of other im-
pression techniques (20). As early as 1999, Jennt and Flack (21) described its use for registering the positions of dental implants intraorally. They compared this technique with conventional impression taking, concluding that photogrammetry offered a valid alternative. Since then the techniques have advanced but have not been accompanied by any develop-
ment of the application of pho-
togrammetry for the purposes of implant dentistry. The present article describes this new system for registering, simply and pre-
cisely, the positions of multiple dental implants.
Photogrammetry allows the registering of the exact three-
dimensional locations of the im-
plants, transferring all the infor-
mation required to fabricate the prostheses directly from the gag-
ning mouth to a computer file. The technique avoids the in-
convenience accompanying conventional impression tech-
niques. There is no need for impression abutments, implant-
ion records, casts, body analogues, trays and im-
pression materials. The PIC-
camera measures angles and distances between the implants and the presence of blood, saliva or any other organic or inorganic residue does not affect meas-
urement accuracy. Avoiding so many procedures and materials reduces the probability of errors.
errors saves time – both the number of visits to the clinic and their dura-
tion – economical and patient comfort and discomfort in comparison with conventional impression taking procedures.
Photographic and video scan-
ers share some of the advan-
tages of photogrammetry. Scan-
ers generate 3D images on the basis of a cloud of points that are able to reproduce surfaces. To join the points they use an al-
gorithm called Best-fit®, which makes as many points as possi-
bile coincide. Although practical evidence is lacking, theoreti-
cally these successive unions of points could cause an accu-
curacy of the open tray technique of 0.57 μm and for open try coping.

References
1. Wee MJ, Aquilino SA, Schnei-
der BL. Strategies to achieve fit in implant prosthodontics: a re-
view of the literature. Int J Pros-
2. Heckmann SM, Karl M, Wich-
mann WM, Winter V, Griep F, 
3. Windhorn RJ, Gunnett TR. A simple open-tray implant im-
4. Acuña K, Cerebri MC. Accuracy and stability of impression techniques for registering the positions of multiple implants allowed the fabrication of a patient with extreme maxillary free end edentulism with a prosthesis of minimum retentive power and no need for any prosthodontic fab-
5. Rubio Serrano M, Alhaj Estela S, Pe-arrocha Diago M, 
6. Freedman M, Quinn F, O’Sullivan M. Single unit abutment screw fixation. A liter-
7. Estela S, Pe-arrocha Diago M, 
8. Jent T, Rubino A, Odén A, Sandborgh-Englund G. Computer assisted design of a prosthesis for a patient with extreme maxillary free end edentulism with a prosthesis of minimum retentive power and no need for any prosthodontic fab-