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

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Abstract
Aim: To describe a technique for determining the positions of multiple dental implants using a system based on photogrammetry, CAD/CAM.

After processing patient and implant data, special abutments (PICabutment®) were screwed onto each implant. The PICcamera® was then used to capture impressions of the implant positions, automatically taking 150 images in less than 60 seconds. From this data, the software automatically described the relative positions – angles and distances – of the implants. Information regarding the soft tissues was obtained from an alginate impression cast in plaster and scanned. A Cr-Co structure was obtained using this technique. After contacting 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 found.

The clinical application of this new system using photogrammetry is presented. Use 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, digital 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 osseointegration of the implant-supported prostheses improves the long-term prognosis of this therapy (1-5).

The classic system for fabricating implant-supported prostheses consists of three stages: impression taking, and after placement of the implant analogues, subsequent casting in plaster to make pressurization transfers. In order to achieve adequate passive fit of the prosthesis, the analogue must be obtained by a correct registration of the three-dimensional position of the implants (6).

Conventional impression techniques use abutments that, screwed onto the implants’ prosthetic platforms and encased 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 unpleasant for the patient (7,8).

Photogrammetry is a novel option for determining the geometry of objects and their spatial arrangement from photographic images. Its precision with which it can measure objects without direct contact.

Photogrammetry is useful in many sciences and fields. It has been applied mainly to topography, but there are many non-topographic applications, including different areas of medicine such as radiology (to improve accuracy), surgery (neurosurgery, plastic surgery, sinus surgery) or rehabilitation (15,14).

In dentistry, 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).

Recently, 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 accuracy of other impression techniques, by analyzing the differences between cast models obtained using different techniques and materials (20). As long ago as 1999, Bert R. and Black T. proposed photogrammetry as an alternative to conventional impression techniques and stated that the use of this technique would be beneficial to oral surgery (21). The purpose of this technique is to register the position of multiple dental implants using a system based on photogrammetry, CAD/CAM and digital milling, and its accuracy has been demonstrated in previous studies (22).

The aim of this article is to present a case of simultaneous multiple implants using a system based on photogrammetry, CAD/CAM and digital milling. After these verifications, the Cr-Co structure was sent to the laboratory to have the ceramic loaded. The prosthesis, once finished was screwed onto the implants (Fig. 2), with 25 Ncm torque. Oclusal adjustments were performed and the correct position of the implant contacts was verified by a radiograph (Fig. 3). A follow-up plan was established and twelve months later, the positions of the implants were registered using the PICcamera®. The correct set was recorded with 25 Ncm torque (Fig. 3). The prosthesis was finished successfully using this technique.

Clinical Procedure
A 55-year-old male with no relevant medical history came to the Oral Surgery Unit of the University of Valencia requesting the rehabilitation of bicuspid right maxillary posterior region with dental implants. After checking the presence of enough residual alveolar bone height by means of a panoramic radiograph, three European植入 (Eurotechnika® Iberia, Barcelona, Spain) implants were placed of 4.4 mm in diameter (Fig. 1). Three months later, the position of the implants was registered using the PICcamera®.

Finally, the patient’s dentures were scanned by the PICcamera® and the design was transferred to the laboratory to make the prosthesis. Three implants were used to place and an alginate impression was taken and cast in plaster. The microscrew implant was placed with a 3D scanner in an open STL format to obtain information regarding the patient’s soft tissues (Fig. 1) and then was processed in CAD/CAM software to build the digital model. The five prosthetic abutments were screwed onto each implant (Fig. 1) and the prosthesis was placed 15.04 mm away from the patient’s mouth with a maxi- mum angle of 45° with respect to the PICabutment®. Once the camera had detected that the position was correct, it automatically captured 50 three-dimensional photographs of the implants (PICcamera®). To this, it automatically takes ten extraoral photographs per second with an error of less than 10 microns. The registered angles and distances between implants are interrelated and treated as a unit.

System software calculates average angles and distances between implants from these photographs, obtaining an accurate relative position of each implant. This information is transferred to the PICcamera® (PIC Dental), which contains all the information on the position of the implant, its geometry, connections, healing abutments and screws that are later required by CAD/CAM software.

Fig. 1. A) View at three months after the placement of three implants in the maxillary right posterior region with posterior maxillary edentulism. Three months later, the positions of the implants were registered using the Sheffield test and its passive fit was verified in the patient’s mouth using the Sheffield test and the screw resistance test.

The prosthesis, once finished was screwed onto the implants (Fig. 2), with 25 Ncm torque. Oclusal adjustments were performed and the correct position of the implant contacts was verified by a radiograph (Fig. 3). A follow-up plan was established and twelve months later, the positions of the implants were registered using the Sheffield test and its passive fit was verified in the patient’s mouth using the Sheffield test and the screw resistance test. Therefore, its application may be a very useful technique that will improve dental implant therapy.

Dental Tribune Middle East & Africa Edition | January-February 2015
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- sion free, configurations between implants and the prosthetic structures they support is a re- quirement for short and long-term success of implant-
supported rehabilitations. This situation is achieved by carrying out a prosthodontic treatment with good passive fit. Particularly, it is achieved by all the clinical and laboratory proce-
dures involved in fabricating the final prosthesis, to be performed precisely and accurately, keep-
ing the margins of error and implant supported structures in the process to a minimum (1,2,2).
In vitro studies have shown that discrepancies in the super-
structure will be the cause of stress on the implantsupported prosthesis and subsequent fail-
ure. As long ago as 1988, Shibli described mechanical failures which he associated with lavo-
rating osteonics and systems using imprese working models. Jenet et al (8) and Rahemen et al. (22) found that the fit between prosthesis and abutment is a key parameter for avoiding overload on the prosthodontic screws which lead to prosthesis failure. For this reason, the taking of im-
pression is an essential step for obtaining structures with a good passive fit. There is some consensus in the literature as to which impression technique is the most reliable.
Recent reviews of implantology with con-
ventional techniques it is impos-
sible to achieve a perfect passive fit (9). A recent review of the precision of im-
pression techniques, found that 55% of the tests performed con-
sidered the open tray technique to be the most precise, 15% the reversed tray technique and 50% found no statistically sig-
ificant difference between the two. The number of implants in relation to precision, with three or more implants there did not appear to be any difference between, with four or more the open tray tech-
nique is considered to be the rec-
 mendable (6). The greater accu-
 racy of the open tray technique is attributed to the efforts of Accep MA et al. (24), who studied aver-
age discrepancy with each type of technique and found, using a cop-
bings of 48.9 μm for repositioning cop-
bings and 57.8 μm for open tray cop-
bings.

The concept of photogrammet-
try consists of “metering what is visible and invisible” obtaining reliable metric in-
formation from photographs. The photogrammetry method extends the two-dimensional information provided by pho-
tographs to three dimensions using various cameras, the shape of each of the photographic ob-
jects, and the spatial positions in space are reconstructed in relation to an external system of reference points. In addition, this is the necessary calculations for reconstruction, special cameras are required that are able to identify this sys-
tem of reference (10). 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 ear-
ly as 1999, Jenet 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 dental implants clinical advances have been considerable but have not been accompanied by any develop-
ment of the application of photogra-
metry for the purposes of implant dentistry. The present article presents a new system for registering, simply and pre-
cisely, the positions of multiple implant impressions.
Photogrammetry allows the registering of the exact three-
dimensional locations of the im-
plants, transferring all the infor-
mation required to fabricate the prosthesis directly from the pa-
tient’s mouth to a computer file. The technique avoids the in-
convenience accompanying conventional impression tech-
niques. There is no need for impression abutments, implant body analogues, trays and im-
pression materials. The PIC-
camera measures angles and dis-
cances between the positions of the im-
plants, allowing the patient to
make as many points as possi-
bles in a cloud of points that are
inexactitude of each step in the
registration process. Avoiding so-
the presence of blood, saliva or
any other organic or inorganic
material freedom of movement and
the possibility of errors occurring during the produc-
tion of the prosthetic structure.
The clinical evaluation of pas-
sive fit between implants and prosthetic structures is difficult to assess. Diverse methods for checking fit have been suggested, but none has been established as a stand-
ard test. In the present case, the Sheffield test and the one-screen resist-
ance test were used to check the fit. The Sheffield test has been shown to be an efficient test of passive fit, especially in cases with multiple implants and extensive prosthetics. The screw resistance test of movement step has the dis-
advantage of introducing sub-
jectivity into the evaluation, but is considered a precise way of detecting discrepancies (28).
Registering implant positions with the PICcamera improves patient comfort in comparison with conventional impression techniques. The tech-
nique avoids the introduction of impression materials which must be kept in place in the mouth for an average time of 5-8 minutes and can pro-
voke nausea and discomfort. Furthermore, the photogra-
meter procedure can be inter-
cutaneous and taken up again later on.

The clinical application of this novel photogrammetry system for registering the positions of multiple implants allowed the reconstruc-
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Fig. 3. A) Placement of the finished prosthesis; B) Radiographic check-up after 12 months.

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DENTAL TRIBUNE Middle East & Africa Edition | January-February 2015

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