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CAD/CAM

international magazine of digital dentistry

2 2013

special
CAD/CAM and growth factors

case report
One-visit guided treatment thanks to CAD/CAM

industry report
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Dear Reader,

Magdalena Wojtkiewicz
Managing Editor

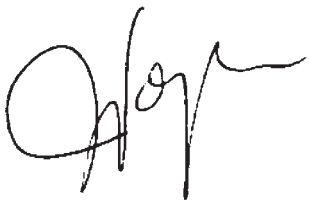
_**This year's most important event** in the dental industry—the International Dental Show (IDS) in Cologne is behind us. IDS once again succeeded in showcasing the highest level of innovation in dentistry, and IDS 2013 was all about digital dentistry.

CAD/CAM procedures now not only offer improvements in preventative care, treatments, and laboratory procedures so important for dental professionals, but also give patients a virtually unprecedented opportunity to see the desired treatment outcome, and experience the benefits of engineering expertise and medical advancement directly.

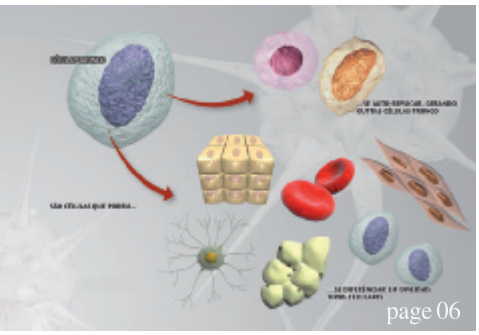
Backward planning, as it is called, is increasingly becoming integrated into dental procedures and dental laboratory processes. The more complex the medical procedures it is used with, the greater the benefits it offers will be. Dental implants are a good example because the treatment outcome depends greatly on consultation. Dentists and dental technicians can now work with data from 2-D and 3-D radiographs captured using CBCT and facial scanners, as well as with data obtained from classic or digital dental impressions. This allows the creation of precise digital surgical guides, for example, that ensure dental implants will be placed in exactly the right position and at precisely the right angle. Any crowns or bridges subsequently seated will be in the optimal position too. In addition, the emergence profile can be designed to have as natural an appearance as possible.

This issue of CAD/CAM discusses some of these new procedures, and I hope that these articles will aid you in applying these methods in your practice to improve your work to your patients' benefit in particular.

Yours sincerely,



Magdalena Wojtkiewicz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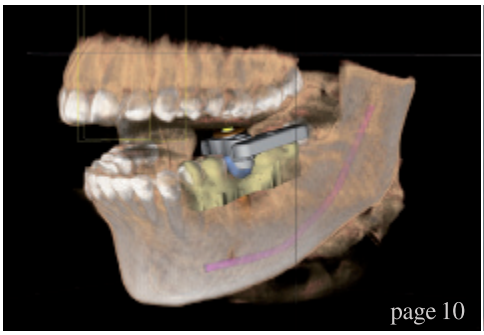
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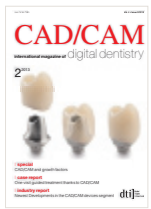

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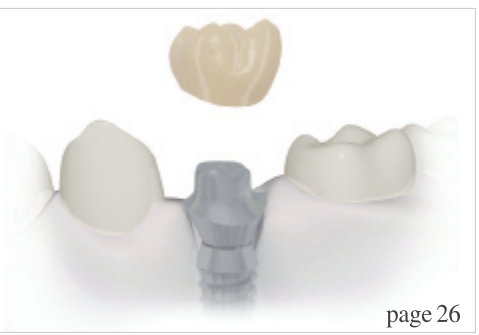
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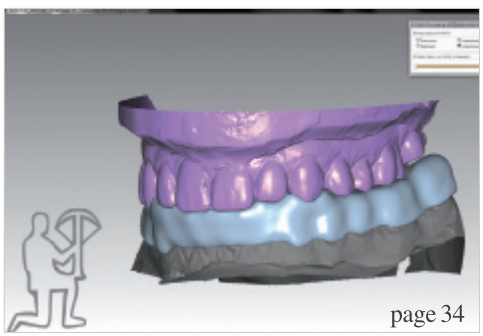
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Stem cells in implant dentistry

Author_ Dr André Antonio Pelegrine, Brazil

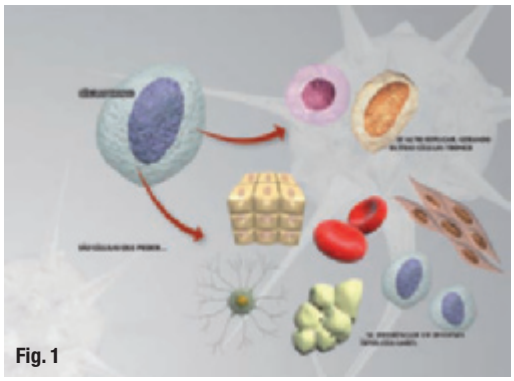
Fig. 1

Fig. 1_A stem cell following either self-replication or a differentiation pathway.

Fig. 2_Different tissues originated from mesenchymal stem cells.
Fig. 3_The diversity of cell types present in the bone marrow.
Fig. 4a_Point of needle puncture for access to the bone marrow space in the iliac bone.
Fig. 4b_The needle inside the bone marrow.
Fig. 5a_A bone graft being harvested from the chin (mentum).
Fig. 5b_A bone graft being harvested from the angle of the mandible (ramus).
Fig. 5c_A bone graft being harvested from the angle of the skull (calvaria).
Fig. 5d_A bone graft being harvested from the angle of the leg (tibia or fibula).
Fig. 5e_A bone graft from the pelvic bone (iliac).
Fig. 6_A critical bony defect created in the skull (calvaria) of a rabbit.
Fig. 7_A primary culture of adult mesenchymal stem cells from the bone marrow after 21 days of culture.
Fig. 8a_A CT image of a rabbit's skull after bone-sparing grafting without stem cells (blue arrow). Note that the bony defect remains.
Fig. 8b_A CT image of a rabbit's skull after bone-sparing grafting with stem cells. Note that the bony defect has almost been resolved.
Fig. 9_A bone block from a musculoskeletal tissue bank

_The human body contains over 200 different types of cells, which are organised into tissues and organs that perform all the tasks required to maintain the viability of the system, including reproduction. In healthy adult tissues, the cell population size is the result of a fine balance between cell proliferation, differentiation, and death. Following tissue injury, cell proliferation begins to repair the damage. In order to achieve this, quiescent cells (dormant cells) in the tissue become proliferative, or stem cells are activated and differentiate into the appropriate cell type needed to repair the damaged tissue. Research into stem cells seeks to understand tissue maintenance and repair in adulthood and the derivation of the significant number of cell types from human embryos.

It has long been observed that tissues can differentiate into a wide variety of cells, and in the case of blood, skin and the gastric lining the differentiated cells possess a short half-life and are incapable of renewing themselves. This has led to the idea that some tissues may be maintained by stem cells, which are defined as cells with enormous renewal capacity (self-replication) and the ability to generate daughter cells with the capacity of differentiation. Such cells, also known as adult stem cells, will only produce the appropriate cell lines for the tissues in which they reside (Fig. 1).

Fig. 2

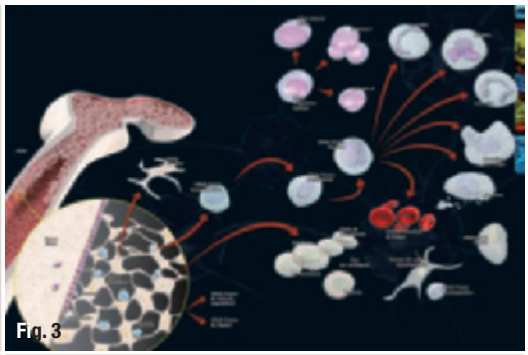
Fig. 3

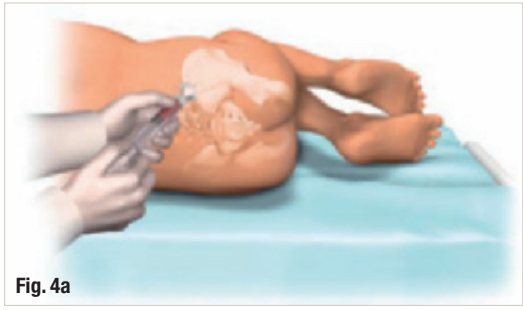
Fig. 4a

Fig. 4b

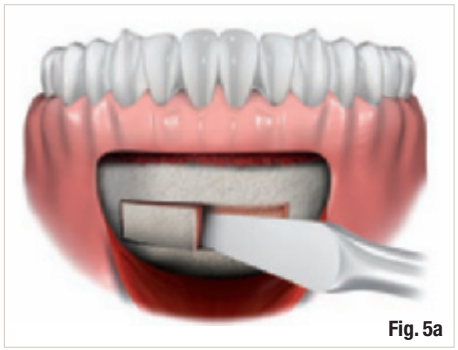
Fig. 5a

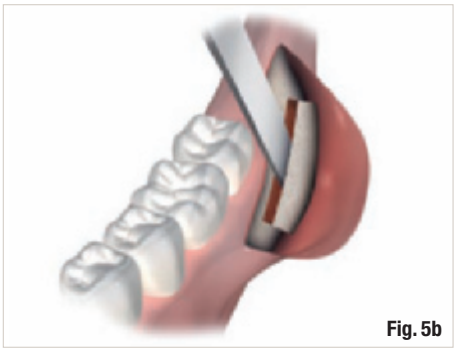
Fig. 5b

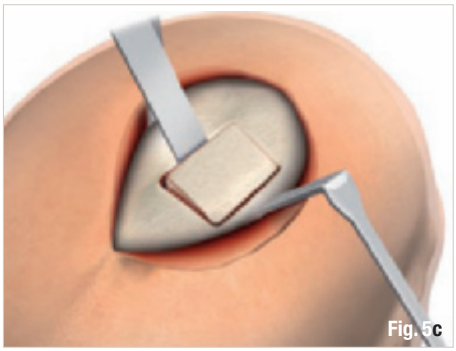
Fig. 5c

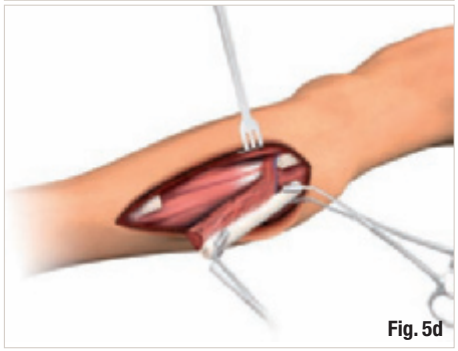
Fig. 5d

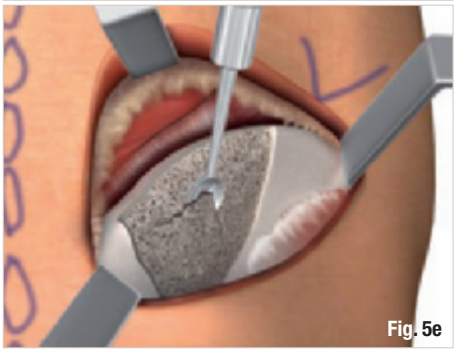
Fig. 5e

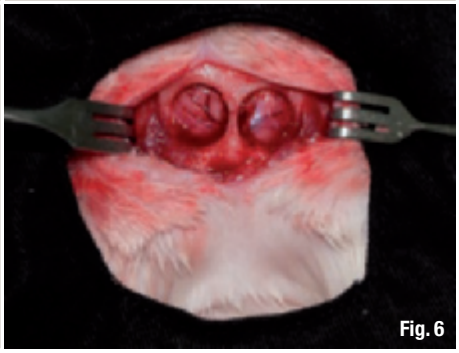
Fig. 6

Not only can stem cells be isolated from both adult and embryo tissues; they can also be kept in cultures as undifferentiated cells. Embryo stem cells have the ability to produce all the differentiated cells of an adult. Their potential can therefore be extended beyond the conventional mesodermal lineage to include differentiation into liver, kidney, muscle, skin, cardiac, and nerve cells (Fig. 2).

The recognition of stem cell potential unearthed a new age in medicine: the age of regenerative medicine. It has made it possible to consider the regeneration of damaged tissue or an organ that would otherwise be lost. Because the use of embryo stem cells raises ethical issues for obvious reasons, most scientific studies focus on the applications of adult stem cells. Adult stem cells are not considered as versatile as embryo stem cells because they are widely regarded as multipotent, that is, capable of giving rise to certain types of specific cells/tissues only, whereas the embryo stem cells can differentiate into any types of cells/tissues. Advances in scientific research have determined that some tissues have greater diffi-

combined with a bone marrow concentrate.

Fig. 10a_A histological image of the site grafted with bank bone combined with bone marrow. Note the presence of considerable amounts of mineralised tissue.

Fig. 10b_A histological image of the site grafted with bank bone not combined with bone marrow. Note the presence of low amounts of mineralised tissue.

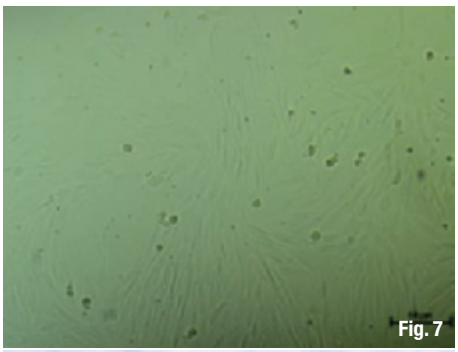
Fig. 7

Fig. 8a

Fig. 8b

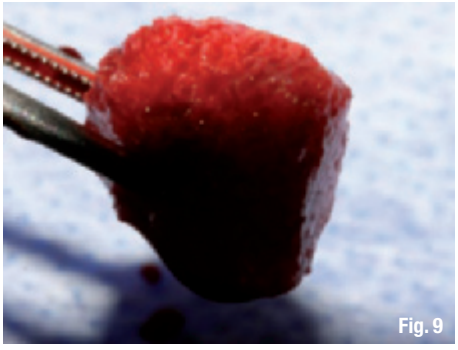
Fig. 9

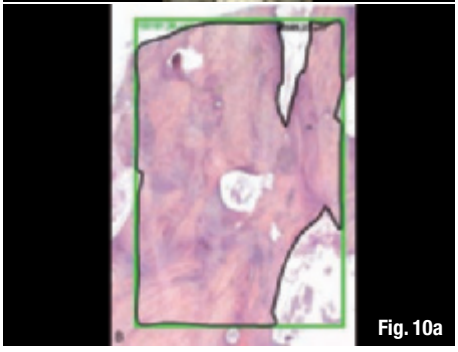
Fig. 10a

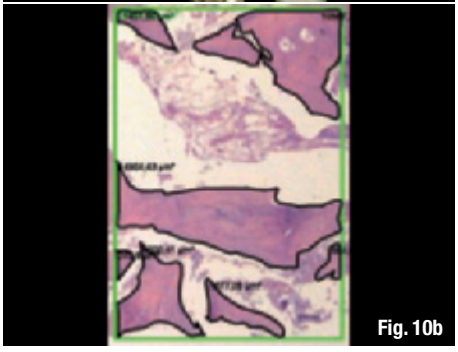
Fig. 10b

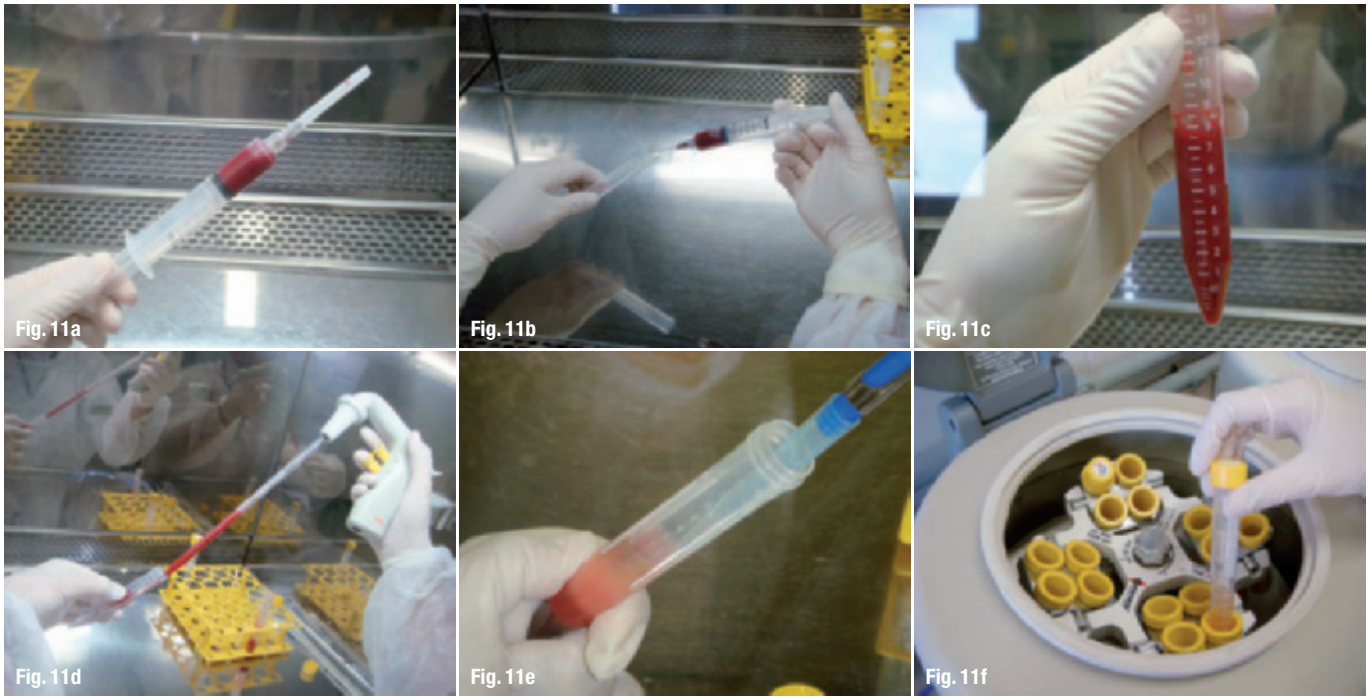

Fig. 11a_Bone marrow.
Fig. 11b_Bone marrow transfer into a conic tube in a sterile environment (laminar flow).
Fig. 11c_Bone marrow homogenisation in a buffer solution (laminar flow).
Fig. 11d_Bone marrow combined with Ficoll (to aid cell separation).
Fig. 11e_Pipette collection of the interface containing the mononuclear cells (where the stem cells are present).
Fig. 11f_Second centrifuge spin.

culty regenerating, such as the nervous tissue, whereas bone and blood, for instance, are considered more suitable for stem cell therapy.

In dentistry, pulp from primary teeth has been thoroughly investigated as a potential source of stem cells with promising results. However, the regeneration of an entire tooth, known as third dentition, is a highly complex process, which despite some promising results with animals remains very far from clinical applicability. The opposite has been observed in the area of jawbone regeneration, where there is a higher level of scientific evidence for its clinical applications. Currently, adult stem cells have been harvested from bone marrow and fat, among other tissues.

Bone marrow is haematopoietic, that is, capable of producing all the blood cells. Since the 1950s, when Nobel Prize winner Dr E. Donnall Thomas demonstrated the viability of bone marrow transplants in patients with leukaemia, many lives have been saved using this approach for a variety of immunological and haematopoietic illnesses. However, the bone marrow contains more than just haematopoietic stem cells (which give rise to red and white blood cells, as well as platelets, for example); it is also home to mesenchymal stem cells (which will become bone, muscle and fat tissues, for instance; Fig. 3).

Bone marrow harvesting is carried out under local anaesthesia using an aspiration needle through the iliac (pelvic) bone. Other than requiring a competent doctor to perform such a task, it is not regarded as an excessively invasive or complex procedure. It is also not associated with high levels of discomfort either intra or post-operatively (Figs. 4a & b).

Bone reconstruction is a challenge in dentistry (also in orthopaedics and oncology) because rebuilding bony defects caused by trauma, infections, tumours or dental extractions requires bone grafting. The lack of bone in the jaws may impede the placement of dental implants, thus adversely affecting patients' quality of life. In order to remedy bone scarcity, a bone graft is conventionally harvested from the chin region or the angle of the mandible. If the amount required is too large, bone from the skull, legs or pelvis may be used. Unlike the process for harvesting bone marrow, the process involved in obtaining larger bone grafts is often associated with high levels of discomfort and, occasionally, inevitable post-operative sequelae (Figs. 5a–e).

The problems related to bone grafting have encouraged the use of bone substitutes (synthetic materials and bone from human or bovine donors, for example). However, such materials show inferior results compared with autologous bone grafts (from the patient himself/herself), since they lack autologous proteins. Therefore, in critical bony defects, that is, those requiring specific therapy to recover their original contour, a novel concept to avoid autologous grafting, involving the use of bone-sparing material combined with stem cells from the same patient, has been gaining ground as a more modern philosophy of treatment. Con-

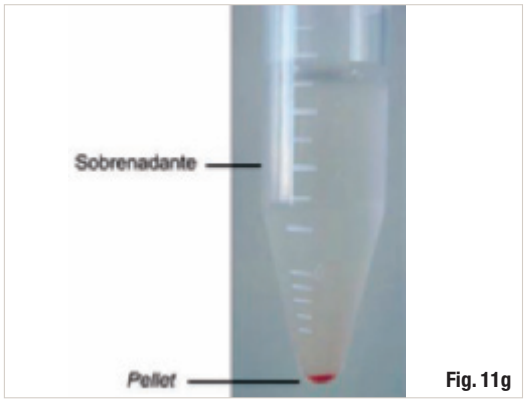

Fig. 11g

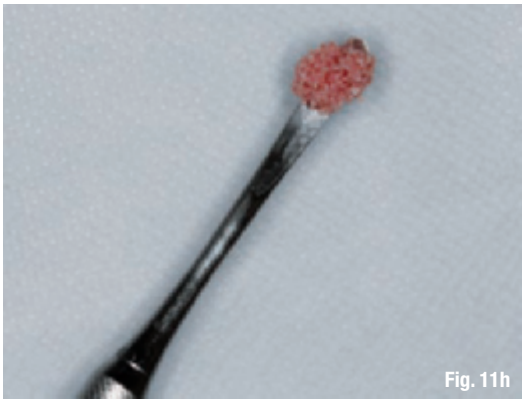
Fig. 11h

Fig. 11g_The pellet containing the bone marrow mononuclear cells after the second centrifuge spin.
Fig. 11h_A bovine bone graft combined with a bone marrow stem cell concentrate.
All images courtesy of Células Tronco em Implantodontia.[2]

sequently, to the detriment of traditional bone grafting (with all its inherent problems), this novel method of combining stem cells with mineralised materials uses a viable graft with cells from the patient himself/herself without the need for surgical bone harvesting.

Until recently, no studies had compared the different methods available for using bone marrow stem cells for bone reconstruction. In the following paragraphs, I shall summarise a study conducted by our research team, which entailed the creation of critical bony defects in rabbits and subsequently applying each of the four main stem cell methods used globally in order to compare their effectiveness in terms of bone healing:[1]

_fresh bone marrow (without any kind of processing);
_a bone marrow stem cell concentrate;
_a bone marrow stem cell culture; and
_a fat stem cell culture (Figs. 6 & 7).

In a fifth group of animals, no cell therapy method (control group) was used. The best bone regeneration results were found in the groups in which a bone marrow stem cell concentrate and a bone marrow stem cell culture were used, and the control group showed the worst results. Consequently, it was suggested that stem cells from bone marrow would be more suitable than those from fat tissue for bone reconstruction and that a simple stem cell concentrate method (which takes a few hours) would achieve similar results to those obtained using complex cell culture procedures (which take on average three to four weeks; Figs. 8a & b).

Similar studies performed in humans have corroborated the finding that bone marrow stem cells improve the repair of bony defects caused by trauma, dental extractions or tumours. The histological images below illustrate the potential of bone-sparing materials combined with stem cells for bone reconstruction (Fig. 9). It is clear that the level of mineralised tissue is significantly higher in those areas where stem cells were applied (Figs. 10a & b).

Evidently, although bone marrow stem cell techniques for bone reconstruction are very close to routine clinical use, much caution must be exercised before indicating such a procedure. This procedure requires an appropriately trained surgical and laboratory team, as well as the availability of the necessary resources (Figs. 11a–h, taken during laboratory manipulation of marrow stem cells at São Leopoldo Mandic dental school in Brazil)._

[1] *André Antonio Pelegrine, Antonio Carlos Aloise, Allan Zimmermann et al., Repair of critical-size bone defects using bone marrow stromal cells: A histomorphometric study in rabbit calvaria. Part I: Use of fresh bone marrow or bone marrow mononuclear fraction,* Clinical Oral Implants Research, *00 (2013): 1–6.*

[2] *André Antonio Pelegrine, Antonio Carlos Aloise & Carlos Eduardo Sorgi da Costa,* Células Tronco em Implantodontia *(São Paulo: Napoleão, 2013).*

_about the author

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