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A Literature Review on Reuse of Dead Bones, Tissues and Bone Grafting

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***Abstract*: This presents a brief overview of the medical and ethical issues involved with in the procurement preparation, safety, efficacy of reuse of bones transplantation after death and the solution that was used for preservation of bones is mostly formaldehyde solution. Whereas bone occurs at a tissue level and is similar to the remodeling of building in that local removal of old bones deposition and the bone transplantation is useful for future were any accidents occurs that tissues was damaged and this transplantation is useful. It is a different situation when cadaveric tissue sampling or organ harvesting is specifically done (outside the framework of the regular autopsy) for scientific or educational purposes.**

***Keywords*: Bone transplantation, Formaldehyde solution, Dead bones preservation.**

1. Introduction

A positive attitude toward organ and, donation tissue transplantation (or) donation would be expected among health professionals from transplant centers with active donor activities. However, acceptance and acknowledge about cadaveric tissue donation has been insufficiently studied [1]. Bone grafting is a surgical procedure that replaces missing bone in order to repair bone fractures that are extremely complex, or fail to heal properly. Bone generally has the ability to regenerate completely but requires a very small fracture space or some sort of scaffold to do so. The principles involved in successful bone graft include osteo conduction, osteo induction, osteogenesis [2].

Bone material properties

- The mineral component is composed of hydroxyapatite, which is an insoluble salt of calcium and phosphorus. About 65% of adult bone mass is hydroxyapatite. * Bone also contains small amounts of magnesium, sodium, and bicarbonate.
- Bone and skin cells can stay alive for several days. It takes around 12 hours for a human body to be cool to the touch and 24 hours to cool to the core. Rigor mortis commences after three hours and lasts until 36 hours after death. Forensic scientists use clues such as these for estimating the time of death.

Chemical composition of bones:

- The major minerals of the intercellular composite are calcium and phosphate. human skeleton: chemical composition of bones Bone is a composite of proteins such as collagen and minerals such as calcium. Together these materials give bone a unique combination of strength and elasticity.

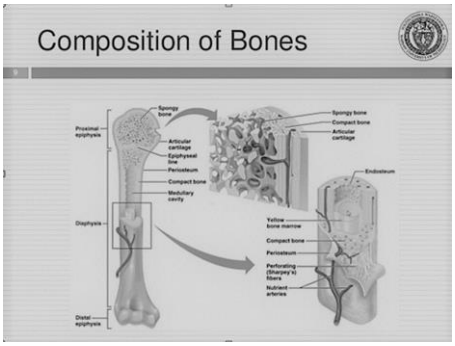

Fig. 1. Composition of bones

- Cadaveric donation comprises organ donation—that is, taking organs (heart, lungs, kidneys, liver, pancreas) from brain dead people, as well as tissue donation, meaning taking tissues (skin, corneas, tendons, bone) from brain dead as well as heart dead people. The organ transplant procedure from brain dead patients is beyond the scope of the pathologist, as it is done by surgeons in the operating theatre. In a broader sense, however, pathologists are involved in cadaveric tissue donation as well as taking tissues from cadavers for diagnostic procedures within the framework of the autopsy (fluids, organs, tissue samples), and to gather material for research and training students and pathology residents (tissues, organs). For cadaveric tissue donation, different ethical and practical issues must be considered, which we will try to review in this paper from the perspective of the pathologist.

2. Cadaveric tissue sampling for transplantation purposes

- Several tissues can be taken from "true" cadavers that may still be used for transplantation such as skin, corneas,

tendons, bone. This is usually done in collaboration with the pathologist, who is in most countries responsible for the body after the death of the patient in the hospital. All these tissues can be harvested several hours after death, as they undergo only slow degradation.

- In The Netherlands, as dictated by law, patients must actively have given permission for donation during life by registering with the Transplantation Register. Since this procedure was implemented, the number of organs available for donation has not increased but decreased somewhat, while the number of tissues has increased.
- A great obstacle to the increase in the number of donations is that only 37% of the population is registered (as either donor or non donor) and that the next of kin almost always refuses donation for the 63% of the population that is not registered, on account of the fact that the deceased has not registered their willingness for this to be done.
- When no autopsy is performed, the procedure of taking tissues for transplant purposes is rather intrusive to the cadaver, except perhaps for the cornea, so it is proper to have permission of the patient for this (given during life), as is the case in our current system in The Netherlands. Alternatively, this should be at least covered by the fact that no objection was registered under a legal "opting out" system.
- In The Netherlands, doctors will usually respect the objection to a donation procedure expressed by the next of kin. This is especially relevant when the patient has not registered with the Transplantation Register. Even if the patient has registered as a donor, however, doctors will usually refrain from a donation procedure if the next of kin objects.
- The most common argument for this is that the next of kin have to live on with the knowledge that some tissues or organs are being used for transplantation, which is emotionally difficult if they feel negatively about this. This argument is only used in refusing donation.
- When a person has registered an objection to donation, and the next of kin are very much in favour of donation, they will have to live on with the knowledge that tissues were not used for transplantation, emotionally difficult or not.
- We think that a parallel can be drawn here with a will. A regular will is always respected, even if the next of kin do not like it. To express the wish to donate organs and tissue for transplantation by signing up with the Transplantation Register can be considered to be the last will of the patient with respect to the body and should be respected as well.
- The taking of tissues for transplant procedures within the framework of the autopsy is still more intrusive than the usual autopsy procedure, as corneas, skin, bone, and tendons are only investigated in exceptional circumstances, so the above considerations can be deemed fully valid.

3. Cadaveric tissue sampling for educational and scientific purposes

- It is a different situation when cadaveric tissue sampling or organ harvesting is specifically done (outside the framework of the regular autopsy) for scientific or educational purposes.
- In these cases, permission from the next of kin should be obtained, as this concerns an additional intrusion to the body beyond regular procedures. In exceptional circumstances, patients themselves give permission for autopsy and tissue sampling.
- In The Netherlands—for example, patients with neurodegenerative diseases may register with the Dutch Brain Bank to donate brain and/or spinal cord tissue for scientific purposes.[4] It is also possible to specifically leave your body to anatomy departments for science and education.
- Osteogenesis only occurs with autograft tissue and allograft.
- Cellular bone matrices. Cadaveric donation comprises organ donation—that is, taking organs (heart, lungs, kidneys, liver, pancreas) from brain dead people, as well as tissue donation,
- Meaning taking tissues (skin, corneas, tendons, bone) from brain dead as well as heart dead people. The organ transplant procedure from brain dead patients is beyond the scope.
- Pathologist, as it is done by surgeons in the operating theatre should take priority over the eventual objections to their use for transplantation from the next of kin.

4. Bone grafting

- Bone grafting is a surgical procedure that replaces missing bone in order to repair bone fractures that are extremely complex, pose a significant health risk to the patient, or fail to heal properly. Some kind of small or acute fractures can be cured but the risk is greater for large fractures like compound fractures Bone generally has the ability to regenerate completely but requires a very small fracture space or some sort of scaffold to do so. Bone grafts may be autologous (bone harvested from the patient's own body, often from the iliac crest), allograft (cadaveric bone usually obtained from a bone bank), or synthetic (often made of hydroxyapatite or other naturally occurring and biocompatible substances) with similar mechanical properties to bone.

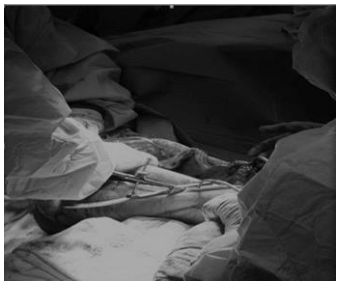

Fig. 2. Bone grafting

- Most bone grafts are expected to be reabsorbed and replaced as the natural bone heals over a few months' time.
- The principles involved in successful bone grafts include osteoconduction (guiding the reparative growth of the natural bone), osteoinduction (encouraging undifferentiated cells to become active osteoblasts), and osteogenesis (living bone cells in the graft material contribute bone osteogenesis only occurs with autograft tissue and allograft.
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Biological mechanism:

- Properties of various types of bone graft sources.
- Bone grafting is possible because bone tissue, unlike most other tissues, has the ability to regenerate completely if provided the space into which to grow. As native bone grows, it will generally replace the graft material completely, resulting in a fully integrated region of new bone. The biologic mechanisms that provide a rationale for bone grafting are:

Osteoconduction:

Osteoconduction occurs when the bone graft material serves as a scaffold for new bone growth that is perpetuated by the native bone. Osteoblasts from the margin of the defect that is being grafted utilize the bone graft material as a framework upon which to spread and generate new bone. In the very least, a bone graft material should be osteoconductive.

Osteoinduction:

- Osteoinduction involves the stimulation of osteoprogenitor cells to differentiate into osteoblasts that then begin new bone formation. The most widely studied type of osteoinductive cell mediators are bone morphogenetic proteins (BMPs).
- A bone graft material that is osteoconductive and osteoinductive will not only serve as a scaffold for currently existing osteoblasts but will also trigger the formation of new osteoblasts, theoretically promoting faster integration of the graft.

Dentin graft:

- Dentin bone, made from extracted teeth, Dentin comprises more than 85% of tooth structure, the enamel consists of HA mineral and comprises 10% of tooth structure.
- Dentin is similar to bone in its chemical composition, by volume 70-75% is HA mineral and 20% organic matrix, mostly fibrous type I collagen. Dentin, like bone, may release growth and differentiating factors while being resorbed by osteoclasts.
- In order to make the dentin graft usable and bacteria-free some companies have developed clinical procedures which include grinding, sorting and cleaning of the teeth for immediate or future use.
- In Korea, the Korea Tooth Bank performed bio-recycling of 38 000 patients' own teeth from January 2009 until October 2012.osteoblasts, theoretically promoting faster integration of the graft.
- In a broader sense, however, pathologists are involved in cadaveric tissue donation as well as taking tissues from cadavers for diagnostic procedures within the framework of the autopsy (fluids, organs, tissue samples), and to gather material for research and training students and pathology residents (tissues, organs).
- For cadaveric tissue donation, different ethical and practical issues must be considered, which we will try to review in this paper from the perspective of the autograft.

Illustration of an autograft harvested from iliac crest

- Autologous (or autogenous) bone grafting involves utilizing bone obtained from the same individual receiving the graft.
- Bone can be harvested from non-essential bones, such as from the iliac crest, or more commonly in oral and maxillofacial surgery, from the mandibular symphysis (chin area) or anterior mandibular ramus (the coronoid process) this is particularly true for block grafts, in which a small block of bone is placed whole in the area being grafted.
- When a block graft will be performed, autogenous bone is the most preferred because there in less risk of the graft rejection because the graft originated from the patient's own body.
- As indicated in the chart above, such a graft would be osteoinductive and osteogenic, as well as osteoconductive. A negative aspect of autologous grafts is that an additional surgical site is required, in effect adding another potential location for post-operative pain and complications.

Autologous

- Bone is typically harvested from intra-oral sources as the chin or extra-oral sources as the iliac crest, the fibula, the ribs, the mandible and even parts of the skull.
- All bone requires a blood supply in the transplanted site. Depending on where the transplant site is and the size of the graft, an additional blood supply may be required.
- For these types of grafts, extraction of the part of the

periosteum and accompanying blood vessels along with donor bone is required. This kind of graft is known as a vital bone graft.

- An autograft may also be performed without a solid bony structure, for example using bone reamed from the anterior superior iliac spine.
- In this case there is an osteo inductive and osteogenic action, however there is no osteoconductive action, as there is no solid bony structure. Chin offers a large amount of cortico-cancellous autograft and easy access among all the intraoral sites.
- It can be easily harvested in the office settings under local anaesthesia on an outpatient basis. Proximity of the donor and recipient sites reductive operative time and cost.
- Convenient surgical access, low morbidity, elimination of hospital stay, minimal donor site di3.

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Fig. 3. Dentin graft

Allografts:

- Allograft bone, like autogenous bone, is derived from humans; the difference is that allograft is harvested from an individual other than the one receiving the graft.
- Allograft bone can be taken from cadavers that have donated their bone so that it can be used for living people who are in need of it; it is typically sourced from a bone bank. Bone banks also supply allograft bone sourced from living human bone donors (usually hospital inpatients) who are undergoing elective total hip arthroplasty (total hip replacement surgery).
- During total hip replacement, the orthopaedic surgeon removes the patient's femoral head, as a necessary part of the process of inserting the artificial hip prosthesis. The femoral head is a roughly spherical area of bone, located at the proximal end of the femur, with a diameter of 45 mm to 56 mm in adult humans.
- The patient's femoral head is most frequently discarded to hospital waste at the end of the surgical procedure. However, if a patient satisfies a number of stringent regulatory, medical and social history criteria, and provides informed consent, their femoral head may be deposited in the hospital's bone bank.
- There are three types of bone allograft available:-
  1. Fresh or fresh-frozen bone
  2. Freeze-dried bone allograft (FDBA)
  3. Demineraliz

Alloplastic grafts:

- Alloplastic grafts may be made from hydroxylapatite, a naturally occurring mineral that is also the main mineral component of bone. They may be made from bioactive glass. Hydroxylapatite is a Synthetic Bone Graft, which is the most used now among other synthetic due to its osteoconduction, hardness and acceptability by bone.
- Tricalcium phosphate which now used in combination with hydroxylapatite thus give both effect osteoconduction and resorbability. Polymers such as some microporous grades of PMMA and various other acrylates (such as polyhydroxylethylmethacrylate aka PHEMA), coated with calcium hydroxide for adhesion, are also used as alloplastic grafts for their inhibition of infection and their mechanical resilience and biocompatibility.
- Calcifying marine algae such as Corallina officinalis have a fluorohydroxyapatitic composition whose structure is similar to human bone and off gradual resorption, thus it is treated and standardized as "FHA (Fluoro-hydroxy-apatitic) biomaterial" alloplastic bone grafts.

Synthetic variants

- Flexible hydrogel-HA composite, which has a mineral-to-organic matrix ratio approximating that of human bone. Artificial bone can be created from ceramics such as calcium phosphates (e.g. hydroxyapatite and tricalcium phosphate), Bioglass and calcium sulfate; all of which are biologically active to different degrees depending on solubility in the physiological environment.
- These materials can be doped with growth factors, ions such as strontium or mixed with bone marrow aspirate to increase biological activity.
- Some authors believe this method is inferior to autogenous

bone grafting however infection and rejection of the graft is much less of a risk, and the mechanical properties such as Young's modulus are comparable to bone.

Temporary spacer:

- A synthetic material may be used as a temporary antibiotic spacer before being replaced by a more permanent material.
- For example, the Masquelet procedure consists of initially using PMMA mixed with an antibiotic (vancomycin or gentamicin) for 4–12 weeks, and then replacing the space with an autologous bone graft. It can be used to treat posttraumatic bone defects.

Xenograft:

- Bone substitute has its origin from a species other than human, such as bovine bone (or recently porcine bone) which can be freeze dried or demineralized and deproteinized.
- Xenografts are usually only distributed as a calcified matrix. Madrepore and or millepore type of corals are harvested and treated to become 'coral derived granules' (CDG) and other types of coralline xenografts.
- Coral based xenografts are mainly calcium carbonate (and an important proportion of fluorides, useful in the context of grafting to promote bone development) while natural human bone is made of hydroxyapatite along with calcium phosphate and carbonate: the coral material is thus either transformed industrially into hydroxyapatite through a hydrothermal process, yielding a non-resorbable xenograft, or simply the process is omitted and the coralline material remains in its calcium carbonate state for better resorption of the graft by the natural bone.
- The coral xenograft is then saturated with growth enhancing gels and solutions. The presence of elements such as strontium can result in higher bone mineral density and

Growth Factors

- Growth Factor enhanced grafts are produced using recombinant DNA technology. They consist of either Human Growth Factors or Morphogens (Bone Morphogenic Proteins in conjunction with a carrier medium, such as collagen).

Recovery and aftercare

- The time it takes for an individual to recover depends on the severity of the injury being treated and lasts anywhere from two weeks to two months, with a possibility of vigorous.

Fibular shaft

- Another common bone graft, which is more substantial than those used for dental implants, is of the fibular shaft.
- After the segment of the fibular shaft has been removed normal activities such as running and jumping are permitted on the leg with the bone deficit. The grafted, vascularized fibulas have been used to restore skeletal integrity to long bones of limbs in which congenital bone defects exist and to replace segments of bone after trauma or malignant tumor invasion.
- The periosteum and nutrient artery are generally removed with the piece of bone so that the graft will remain alive and grow when transplanted into the new host site.
- Once the transplanted bone is secured into its new location it generally restores blood supply to the bone in which it has been attached.

Others:

- Besides the main use of bone grafting – dental implants – this procedure is used to fuse joints to prevent movement, repair broken bones that have bone loss, and repair broken bone that has not yet healed.
- Bone grafts are used in hopes that the defective bone will be healed or will regrow with little to no graft rejection. Exercise being barred for up to six months. Enhanced osteoblast proliferation in vivo.

5. Solution that was used for bone preservation

Compare the bone graft cryopreservation method with a preservation method using 98% glycerol solution at room temperature, by testing the antibacterial and fungal effects of 98% glycerol and comparatively analyzing the observed histological changes resulting from the use of both methods.

- Formaldehyde solution was also used and this does not damage the bone composition.

6. Conclusion

Insufficient knowledge about cadaveric tissue was demonstrated among health professionals more exposed to the donation process. This result highlighted the importance of health professional’s education to facilitate public information about organ and tissue donation.

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