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Designed by: Hind Alabbadi

**MAXILLOFACIAL RECONSTRUCTIVE SURGERY**

Today we will talk about maxillofacial reconstructive surgery/bone grafting.

Bone graft is really essential for all surgeon, dentists, periodontists, for everybody, because in many cases we will face bone loss. How to deal with defects in alveolus in mandible or maxilla? There are many techniques and many materials used, new materials that come up every year, so it’s important to discuss the concepts, what we mean by reconstruction? How we approach it? For both the minor level ex: reconstructive dental implant, and for the major level ex: reconstruction of pathological lesions, or after trauma, or after cancer surgery … etc.

\*\*Remember always that reconstructive surgery is not about reconstructing the bone only, in our area we deal with head and neck which is a very dynamic structure; the face which include the muscles, nerves, bones, skin, animation, it’s not only a static structure that we are aiming to reconstruct. Therefore, we talk about the form as well as the function (animation, speech, swallowing, chewing) so we usually think about bone as well as skin replacement, muscle, soft tissue, teeth, and nerve function.  
\*\*For this lecture because of the time, and the level of under-grad education, we will focus mainly on bone physiology and bone management in these cases.  
  
How do we usually replace bone?(Methods of bone reconstruction)  
-Local manipulation🡪any borrowed bone from adjacent structures to fill the defect.  
-Extensive grafting🡪 take a large blocks of bone from distant areas (ex: radius, hip).  
-Distraction osteogenesis🡪 trying to stimulate bone formation by using distracter.  
-Tissue engineering🡪new modalities of producing either osteoinductive materials or new bony materials by advanced technology, trying to enhance the formation of new bony material without the need to take from other sites?.

Generally bone grafts are classified into:  
-Autogenous bone graft.  
-Allograft.  
-Xengraft.  
-Alloplastic materials.

\*Autogenous bone graft:  
-From the same patient, so it has a good genetic match, so rejection principle is not there.  
-3 mechanisms of bone healing( osteoinduction, osteoconduction, osteogenesis)   
remember the bone physiology, we take a small piece of bone and transfer it from one site to the other, what happens to that bone? The bone has organic materials(ex: collagen with its types), minerals components(ex: HA and other minerals), and also cells(ex: osteoprogenitor cells), bone morphogenetic proteins, osteoinductive materials. All are present usually in autogenous bone graft, therefore it’s the best bone graft to be used because it has the free potential to enhance new bone formation, they are osteoinductive; they stimulate new bone formation by having the osteoprogenitor cells, ???????? that stimulate the new bone formation, osteoconductive; they act as networks –scaffolds- that new bone will form above them, and also osteogenic; they have bone cells that will stimulate new bone formation, so they are 3 in 1.  
Especially when we have a good amount of cancellous bone which is very rich in these components.  
-The disadvantages: donor site morbidity, prolonged operating time and lower patient acceptance rate (especially in elective surgeries; ex: taking a graft for implant surgery from the chin. But in advanced surgical reconstruction(ex: reconstruction of mandible/maxilla after trauma or malignancy), patients don’t have a choice ).

\*Allografts:  
-It’s a cadaveric bone, therefore it’s taken from the same species, genetically different that’s why they are treated with many techniques (not taken as it’s): fresh, frozen, freez dried(lyophilized), mineralized or demineralized.  
-sold in different forms; blocks, pastes, injectable…..  
-osteoconductive usually( but some believe that has some osteoinductive features).  
-Advantages: No donor site morbidity, shorter operating time.  
-Disadvantages: No osteoprogenitor cells, many patients refuse to have cadaveric grafts.  
(These grafts usually get screened for AIDs, hepatitis and many other diseases)

\*Xenograft:  
-Different species (bovine/porcine).  
-Osteoconductive features, no osteogenic or osteoinductive potential.  
-derived from inorganic portion of bone.  
-share many advantages of allografts, but the tendency to ingrowths connective tissue is more, and the efficacy compared to allograft is debatable.  
-can have increased connective tissue ingrowth (which will weaken the bone graft and make the quality worse), delayed vascularisation, delayed resorption(we need it to resorb so it can be replaced by new bone).

\*Alloplastic materials (synthetic bone grafts):  
-sources: coral…  
-non biological materials, HA, calcium sulfate and bioactive glass.  
-fewer indications for use, ex: in implants. The outcome is probably worse than other materials, their physiological turnover is not really favorable (that is why they have limited uses in certain conditions but it can be used widely in surgeries, for ex: in combination of autogenous bone graft, in some cases where the defect is large, we take blocks from the chin in addition to synthetic bone to enhance the osteoinduction and osteoconduction, and provide a good volume of bone).

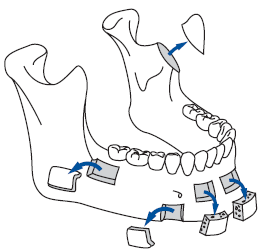
((We need to be aware of the four types, but generally speaking surgeons always tend to have the autogenous bone graft as the main option, it’s the golden standard for treatment because it gives the best results))

**Cortical vs. cancellous bone graft**

Cortical bone graft:  
- can be taken from the chin, ramus…  
-Advantages: high concentration of BMPs which has a good osteoinductive potential , easier rigid fixation, initial graft stability, and development of a good quality of bone (D1 , D2 bone)in recipient site.  
-Disadvantages: reduced osteogenic activity and less vascularity, high failure with early exposure/dehiscence, need contouring, slow revascularsation, and incomplete bone replacement.  
(but it still a good option to use in reconstruction of the alveolus especially in cases of dental implants and to recontour the alveolus and restore the 3D shape of the bone)

Cancellous bone graft:  
-taken from maxillary tuberosity(behind the last molar you make a subperiosteal incision, we avoid the fat of the cheek then take a good bulk of cancellous bone from the tuberosity)🡪 surgical risks: pterygoid venus plexus damage and sinus exposure.  
also taken by trephine from intraoral sites(make a hole in the bone then get a bulk from cancellous bone by something like the suction tube). Also bone scraping ( from ramus and tuberosity), even allografts, xenograft and alloplastic sources.  
-High osteocompetent cells (it’s very vascular, we use it in cleft palate cases to get the best outcome. we take it from the iliac crest, we don’t worry about movement, it’s highly vascular and has high osteogenic, osteoinductiveand osteocnductive potential, usually after 6 months there will be good stability and good formation of new bone which will allow later the canines to erupt).  
-Disadvantages: no rigid fixation, need for membranes and meshes that will keep the shape(the membrane has also its problems of dehiscence and exposure), lack of stability and structural support.  
(Companies now try to make it in different forms; pastes, injectable, and add different materials to make it more malleable so surgeon can use it easily and be able to maintain the space).   
-Heals via rapid incorporation- rapid vascularsation and increased osteogenesis.  
(cortical bone graft heals by what is called “creeping”, spaces in cortical bone are limited, therefore the vascularity is limited, usually necrosis happens then there will be replacement by new bone. While cancellous bone has a lot of spaces inside, can be easly be invaded by new vessels and formation of bone is much faster , so necrosis is more rapid in comparison to cortical bone).

The first 4 types we mentioned are used more in minor oral surgeries. When we talk about maxillofacial surgery and major surgeries, probably we need larger chunks of bone, therefore we have 2 options for autogenous bone graft (vascularized vs. non vascularized).  
All what we mentioned before was non vascularized bone grafts(we take the bone and put it in site without blood supply, just free transfer to the recipient site )

**Non vascularized bone graft:**-Non-vital bone grafts harvested without a blood supply, gain this from the recipient bed.  
-Donor sites:  
\* intraoral donor sites🡪 most commonly chin (you can take 2-3 blocks, you make sulcular incision or vestibular incision, remember to be away from mental nerve, it can be done under LA). Advantages:blocks are corticocancellous and it can provide large amount of bone with good quality.  
🡪anterior ramus(just behind the last molar make an incision and go up then take a block from ramus). It’s a cortical bone but still a good option.  
🡪coronoid.   
🡪tuberosity.  
🡪anterior nasal spine.  
(You can take from anywhere in the oral cavity, also depends on the surgery; if you have a flap in somewhere else that is already open, you can take bone from there).  
\*Illiac crest .  
\*Rib (especially in condyle reconstruction. Ex: in temporomandibular joint ankylosis; we take the rib with the overlying cartilage, hoping that the growth of the mandible will continue. Sometimes we have overgrowth or deviation to the other side, or osteomyelitis and resorption of bone. But it’s usually the golden star in these cases).  
\*Outer table of calvarium.

What happens to the bone graft when we put it in place?  
***Biology:***   
Bone cells survive for 5 days  
Central parts of large grafts become necrotic then become revascularised within weeks to months then it gets replaced by new cells and new bone from Osteoprogenitor cells, and undifferentiated mesenchymal cells that will come to the area and start formation of new bony cells that replace the old bone.( differentiate into bone producing cells (inductive period) )

*Criteria for success* :  
-Firm fixation🡪 if any mobility there will be a high tendency for resorption, blood supply and reunion with adjacent bone won’t be easy, the physiological revascularization will be disturbed . (Usually we use at least 2 screws for cortical bone graft, one on each side so rotation won’t occur. But in cancellous bone you can’t really fix it with screws, you have to put mesh or membrane to fix it).  
-Intimate contact to recipient site🡪 to obtain blood supply from adjacent bone  
-Minimal contamination🡪 if dehiscence occurs there will be high probability of failure because of contamination.

**Vascularized bone graft:**  
(used in reconstruction of large defects).  
-Radial forearm 🡪 take the radius with its artery, vein, skin and muscle(as a composite graft), then ligate it in recipient site, and ligate the tissue artery and tissue vein. So it become like healing, not like in free graft that will have necrosis and get replaced.  
-Iliac crest (DCIA)  
-Scapular  
-Fibula  
\*\*we can use it in SSC in the mandible, started from the mucosa and invaded the bone(stage 4), so here we resect the body of mandible with the mucosa and part of floor of the mouth. In this case if we use a free bone graft, how can we replace the soft tissue? Soft tissues conventionally can be taken from temporalis, pectoralis major…   
it’s a complicated procedure that will make deformity to the patient, so now in vascularised graft we take the whole block with the muscle and suture the skin, floor of the mouth, and fix the bone, and connect under the microscope the facial artery with for example the radial artery. You will have better healing and better resistance for radiation (if autogenous bone graft was used with radiation, osteoradionecrosis will occur because of compromised blood supply).\*\*

This is the same principle as in facial transplant (take facial structures including veins, arteries and nerves, and connect under microscope the donor organ with the recipient hoping that healing and vascularisation happen). Ex: the first case of facial transplant is of a woman with a huge dog bite in the face(lost her nose and lips). The problem here is the same as of allografts, you are talking about genetic mismatch, these patients are taking very high doses of immunosuppressant, so they are at higher risk of malignancies. This is the ethical debate for cases of facial transplant. The future is moving toward tissue engineering instead of facial transplant for these cases.

In mandible reconstruction:  
-where we have continuity bone loss- we need a large block from iliac crest.  
-In joint replacement we need costochondral graft.

In maxilla reconstruction:  
we can take from many spaces, we have an ex in the slides of taking Iliac crest bone graft.

\*\*Iliac crest bone graft is a very simple procedure, we take a good part from iliac crest either cortical or corticocancellous (in slides, a very rich cancellous bone about 4cm in size from iliac crest) depending on the procedure, takes 30 minutes only, good in cleft cases and reconstruction, it can be done easily. Then close and transfer it to the mandible(the case in slides), the patient has asymmetry in the mandible, so they did elongation for the ramus, and fill the gap with bone graft from the iliac crest, then rigid fixation.

\*\*In cases of clefts, bone graft placement is usually at age of 11years, but the oronasal soft tissue closure is done before that age.

**\*\***there is another ex in the slides of using iliac crest bone graft in elongation of the chin (genioplasty).

\*Alloplastic materials: (we talked about them before)  
Hydroxylapatite crystals  
Bioactive glasses  
Calcium sulfate  
Beta tricalcium phosphate  
Biphasic calcium phosphate

**Tissue engineering:**-there are many options for tissue engineering products, the most successful until now is Bone morphogenetic proteins (BMPs) and their derivatives BMP-2,BMP-7, many derivatives are now used as osteoinductive materials.  
  
-BMPs are cell mediators that work on mesenchymal cells, which are raw materials (not differentiated). Mesenchymal cells in the normal process take time until they become osteogenic cells, this process theoretically can be accelerated by multiplying the concentration of BMPs molecules that get inside the mesenchymal cells and stimulate the nucleus to transform into osteogenic cells in a faster way.(this is the principle of applying BMPs, they are trying clinically to use them on for example a defect in the alveolus, theoretically it will produce more bone in a faster way).Now it’s available but it’s too expensive.  
  
-Another technique is using Platelet rich plasma, the principle is that the blood is rich in concentration of tissue mediators and osteoinductive materials, so it’s centrifuged and then applied on the defect; theoretically you are increasing the stimulation of bone formation and transformation of mesenchymal cells into osteogenic cells, so making the procedure much faster.

**Distraction osteogenesis**:  
 it can be applied with dental implants, with bones, you can elongate the bone of maxilla/mandible…………………  
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In our department we use computer assisted surgical planning in cases of bone grafts.

Case 1:  
This patient came with a history of ameloblastoma in the mandible, treated with resection and Iliac bone graft. But then he came complaining from asymmetry, so the bone graft worked but the outcome wasn’t good for him(we need to restore not only the function , we should think about the appearance and patient quality of life too). So we did computer assisted planning and took CT scan for him, 3D printing of his jaw based on the CT, and then on computer we did mirror image of the normal side; in order not to guess during surgery how the shape of mandible will be. We resected the old bone graft, then on the new mandible we placed a titanium mesh, then the plan was transferred to the patient mandible with iliac bone graft. By doing this we hope to correct the asymmetry not only the defect.

Case2:  
This patient was treated 12 years ago from ameloblastoma in the mandible, at that time we didn’t have the option of computer surgical planning, we did for him resection of the bone, then placed a reconstruction plate and bone graft, and after that he had the same problem of facial asymmetry with healed bone. He came back and we did for him the same procedure of computer assisted surgery(CT scan, 3D reconstruction…..)

Case 4:  
This patient had a history of rhabdomyosarcoma in the left cheek, he was treated when he was young by radiation, that affected the growth of the zygoma and mandible, so he had an atrophic zygoma and body of the mandible. For the zygoma we have many options; we can place bone graft, silicone, medpore..etc  
We chose to go for the similar technique by computer assisted planning, we made mirror image of the normal side and make the zygoma prosthesis , and then placed silicone on temporalis defect.  
  
A question about this case that the new zygoma seems a little bit bulgy? The answer was because he didn’t have the surgical correction for the mandible yet, and also the shape is exactly as the other side’s shape –remember that halves of the face are not symmetrical in most of people as the literature says- so one of the limitations of this technique is that it rely on the other side, but it still works.

At your level it’s necessary to know the difference between the types of bone grafts in general, sources, how do they work in the recipient site, the bone physiology, the options and limitations, the applications in oral surgery and maxillofacial surgery.  
So you have the basic principles to understand (when you attend any conference or seminar) why is this company/product is better than the other, there is no black or white so you can’t say this is always bad or always good but you can know when to use each one of them.

**The End  
Good Luck**