BONE GRAFTS

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Terminologies….

Osteogenesis

refers to the formation of new bone by cells contained in the graft

Osteoinduction- is a chemical process by which molecules contained in the graft (BMPS) convert the neighboring cells into osteoblasts which in turn form bone.

Osteoconduction- is a physical effect by which the matrix of the graft acts as a scaffold that favours outside cells to penetrate the graft and form new bone.

- Osteopromotion describe the use of physical means to seal off an anatomic site – the site where the bone is intended to be (re)formed – to prevent other tissues , notably CT, from interfering with osteogenesis as well as to direct bone formation.

- Osteostimulation is the active stimulation of osteoblast proliferation and differentiation as evidenced by increased levels of DNA synthesis and of the osteoblast markers osteocalcin and alkaline phosphatase.

Sequence of Events in the Healing of Bone Grafts

Blood clot formation

OSTEOGENESIS

Osteoblasts in the transplanted bone having adequate blood supply &cellular viability

OSTEOINDUCTIVE

the recruitment of the mesenchymal cells are differentiated into bone and cartilage forming cells.

Modulated by BMP'S

OSTEOCONDUCTIVE

provide structural and mechanical support

function as Scaffold

CREEPING SUBSTITUTION occurs

Neo vascularization

Cytodifferentiation

Bone Remodelling

REQUIREMENTS:

- Be biocompatible
- Serve as scaffold
- Be resorbable
- Be osteogenic
- Be radiopaque
- Be easy to manipulate
- Non Allergenic
- Not support the growth of pathogen
- Hydrophilic
- Availability in particulate & molder forms
- Microporous
- Have high compressive strength
- Act as a matrix or vehicle for other materials

Ideal characteristics of a bone graft:

- ✓ Nontoxic
- ✓ Nonantigenic
- ✓ Resistant to infection
- ✓ No root resorption or ankylosis
- ✓ Strong and resilient
- ✓ Easily adaptable
- ✓ Ready and sufficiently available
- ✓ Stimulate new attachment and be able to trigger osteogenesis, cementogenesis and formation of a functional periodontal ligament

SELECTION OF GRAFT MATERIAL *[Schallorn 1976]*

Predictability

Accessability - Ease Of Obtaining Material

Availability - Quantity Of Material Obtained

Safety

- Biologic Compatibility
- Immunologic Acceptability

Rapid Vascularization

Resorbability

OBJECTIVES

Increase the bone level

Decrease crestal bone loss

Increase CAL gain

Decrease probing depth

Support formation of new attachment apparatus

HISTORY OF BONE GRAFTS

The First Recorded Attempt To Use Bone - Dutch Surgeon Job Van Meekren In 1668

Autogenous (Extra Oral) – First For Periodontal Application (Zolton Hegedus, 1923)

Allogenic Freeze Dried Bone - (James Mellonig & Gerald Bowers 1976 – FDBA)

Demineralized Allogenic Freeze Dried Bone (DFDBA) - (Urist)

Xenograft- Forsberg 1956, Melcher 1962

Alloplast Bone Substitutes – White & Shore (1986)

von walter 1882 described use of cortico -cancellous bone graft

BEUBE & SILVER 1936 – Used dry cow bone powder in intrabony defects

DEFINITION:

Bone graft may be defined as that material of animal origin or synthetic preparation of inorganic or organic nature, that may be living or nonliving, and which when seated into a bone defect or soft tissue will stimulate formation of new bone & filling of the defect.

CLASSIFICATION:

BASED ON THE ORIGIN

Autograft - Obtained from the same individual
Allograft - Obtained from different individuals of same species
Xenograft - Obtained from different species
Alloplasts - Synthetic graft materials

BASED ON THE MODE OF ACTION

Osteogenic graft - Cells in the bone graft
Osteoinductive graft - Proteins or growth factors.
Osteoconductive graft - The graft acts as a scaffold
Osteoneutral graft - Fills the bone defect without producing any effects.

BASED ON THE BIORESORPTION

Fast resorbing - 8 to 10 weeks
Slow resorbing – Stay for many months
Non resorbing - Do not resorb for years

Osteogenic	• AUTOGRAFT
osteoinductive	• AUTOGRAFT • ALLOGRAFT
osteoconductive	• XENOGRAFT, • ALLOPLASTS

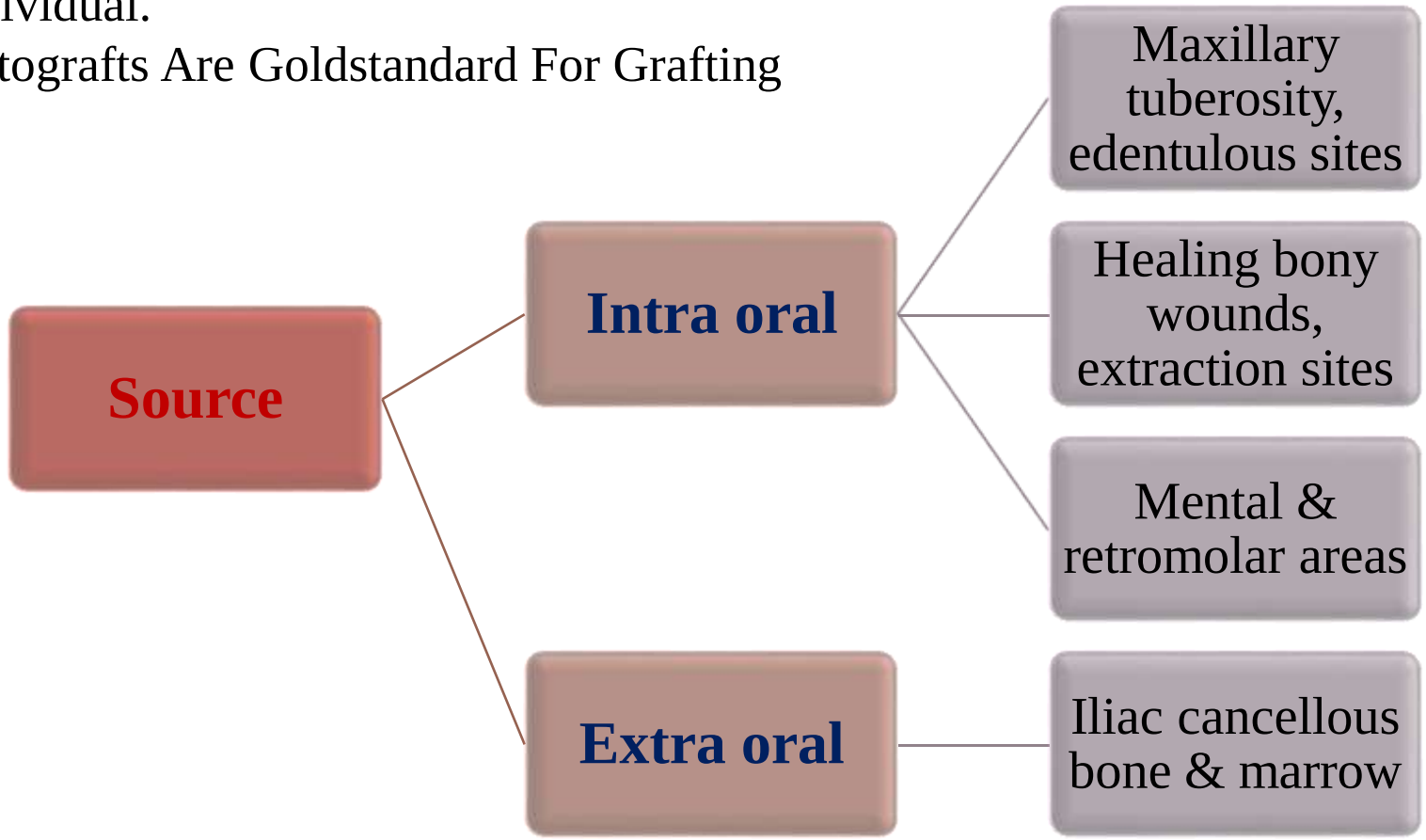
Indications:

- Deep intraosseous defects of varying morphology.
- Shallow intraosseus defects.
- Furcation and shallow wide crater defects.
- Ridge augmentation.
- Combined procedure with GTR.
- Periimplant regeneration.

Autogenous bone graft

An autograft is tissue transferred from one location to another within the same individual.

Autografts Are Goldstandard For Grafting



Methods of procuring graft

- Trephine burs
- Bone scrapers
- Bone collectors
- Rotary instruments
- Bone chisels
- Rongeur pliers
- Piezoelectric devices

Grafted Autogenous bone can be:

- Trabecular
- Cortical
- Corticocancellous

Cortical Bone:

It provides an osteoconductive medium with minimal osteoinductive and osteogenic properties.

Poorly osteogenic:

- Relatively slow revascularization.
- limited perfusion

It has fewer surviving osteogenic cells but provides the most bone morphogenetic protein (BMP).

Cancellous Bone:

Most commonly used source of autogenous graft.

It provides an osteoinductive, osteoconductive, and osteogenic potential.

The porous trabeculae are lined with functional osteoblasts, resulting in a graft that is highly osteogenic.

Cortico-cancellous Block grafts:

CORTICAL BONE
(osteoconductive medium and immediate structural stability)
+
CANCELLOUS BONE
(osteoinductive and osteogenic capabilities)

✓It can be shaped and trimmed to fit the recipient bed.
✓The trabecular part is placed to face the recipient bed.

PARTICLE SIZE OF AUTOGRAFTS

BONE BLEND	210*105 µm
GRAFTS OBTAINED USING BURS	300-500 µm
HAND-CHISELD	1559*783 µm

Osseous Coagulam

- Robinson (1969) - mixture of bone dust and blood
- Particle size - 100 microns
- Use carbide bur No 6 and 8 at speeds between 5,000 and 30,000 rpm.

ADVANTAGES:

Smaller particle size – increased surface area for the interaction of cellular and vascular elements

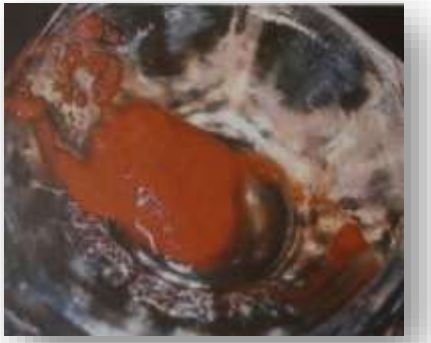
Ease of obtaining the graft from an area already exposed during surgery

DISADVANTAGES:

Aspiration problems.

Inability to procure adequate material for larger defects.

Relatively low predictability



Bone Blend

- Diem et al 1972
- Cortical or cancellous bone that is procured with a trephine or rongeurs, placed in an amalgam capsule, and triturated to the osseous mass. The final particle size is about 210 × 105 mm .

ADVANTAGE:

Adequate amount of material can be obtained

Bone Swaging

- Bone from an edentulous area adjacent to the defect is pushed in contact with the root without fracturing the bone at its base.

- **Disadvantages**

  - Technically difficult
  - Limited usefulness

Advantages of autografts:

- Promotes osteogenesis.
- Risk of disease transfer avoided.
- Can be easily procured.

Disadvantages of autografts:

- Possible root resorption & ankylosis-in case of Fresh illac bone grafts when placed near root surface.
- Inadequate graft material from intra oral sites.
- Second surgical site

HEALING OF AUTOGENOUS GRAFTS
(DRAGOO & SULLIVAN)

- 7 DAYS- Initiation of bone formation
- 21 DAYS- Cementogenesis
- 3 MONTHS - New periodontal ligament
- 6 MONTHS- Radiographic evidence of increasing bone density
- 8 MONTHS- Graft is incorporated into host bone with functionally oriented fibers between bone and cementum.
- 2 YEARS- Maturation of graft site

studies

- Trombelli et al. (2002), compared autogenous bone grafts to open flap debridement procedure and the results indicated a greater clinical attachment level (CAL) gain for grafted group.

- In the systematic review by Reynolds et al. (2003), Autogenous bone treatment resulted in significantly greater clinical attachment level gain.

- ALLOGRAFTS:

Obtained from different individuals of same species

3 FORMS OF ALLOGRAFTS:

Fresh Frozen Bone allograft
Mineralized freeze-dried bone allograft (FDBA)
Demineralized freeze-dried bone allograft (DFDBA)

Fresh Frozen Bone Allograft

Provides the highest osteoconductive and osteoinductive potential among all allograft materials.

Atrophic maxillary ridges grafted with human block allografts of tibia and fresh-frozen chips

Showed development of mature and compact osseous tissue surrounded by marrow spaces

Due to the risk of disease transmission, fresh-frozen allografts are not used anymore.

FREEZE DRIED BONE ALLOGRAFTS (FDBA)

- Introduced in 1976 by James Mellonig et al.
- Freeze drying removes >95% of water content but it preserves major specimen.
- Provides an osteoconductive scaffold when implanted in mesenchymal tissues

Soft tissue stripping -(Removes residual muscle)

Initial size reduction -(Reduces the bone - 5 mm diameter)

Initial cleansing & decontamination -(Saline, acetone,hydrogen peroxide to remove residuaes and reduce antigenicity)

Microbiological treatment -(antimicrobial and antifungal solutions)

Freezing- (Freezes the bone particles in liquid nitrogen as low as −80°C)

Dehydration- (to eliminate moisture content and reduce antigenicity)

Secondary size reduction-(Reduces the bone particles to final particulate sizes ranging between approximately 250 and 750 mm)

Packaging -(Packages the bone allograft in sterile containers)

Terminal sterilization- (Applies low-dose γ - irradiation at low temperatures to ensure sterility)

DEMINERALIZED FREEZE DRIED BONE ALLOGRAFTS

- Demineralization of a bone allograft exposes bone morphogenetic proteins within the bone matrix. These inductive proteins induce a cascade of events leading to cellular differentiation and the formation of bone through osteoinduction by inducing pleuripotential stem cells to differentiate into osteoblasts (Mellonig et al. 1992; Nasr et al. 1999).

ADVANTAGES:

Greater PD reduction

Greater CAL gain

Greater osseous regeneration

(DFDBG) Processing

Demineralization-(Immerses the allograft particles in a hydrochloric acid bath at concentrations ranging from 0.5 to 0.6 normal for various lengths of time)

↓

Buffering-(Immerses the demineralized allograft particles in buffering solution to remove residual acid)

↓

Final rinse-(Rinses the demineralized allograft with various solutions (e.g., distilled water to remove residual buffer solution)

↓

Packaging

↓

Terminal sterilization

STUDIES:

Wood and Mealey stated that no significant differences seen histologically after 4 months, when comparing changes in alveolar ridge dimensions of the either DFDBA or FDBA groups when selective grafting done in the extraction sockets.

DFDBA had a significantly greater percentage of vital bone at 38.42% versus FDBA at 24.63%. And concluded as, DFDBA has significantly greater new bone formation

Particle size of Allograft

Most appropriate particle size ➡ **100-400 µm**

Small particle size may enhance osteogenesis compared to larger particles (1000-2000 µm)

large surface area and ideal pore size between particles ➡ **Allows Increased vascularization to occur**

- ✓ Too Small particles may get resorbed too fast
- ✓ Too Large particles may hinder vascularization and may be sequestered

Advantages of Allograft

- Avoidance of a secondary donor site
- Reduced surgical time
- Decreased blood loss
- Decreased host morbidity
- Unlimited supply of graft material.

Disadvantages of Allograft:

- Not osteogenic
- Bone formation usually takes longer
- Results in less regeneration than autogenous grafts.
- With allografts, concerns have been raised regarding the possibility of disease transmission through grafting.

Commercially available as,

- Puros - Block Graft
- Zimmer Dental - Particulate Graft
- Grafton - Block Graft
- Biohorizon- Particulate Graft

HEALING FOLLOWING ALLOGRAFTS

DAY 1-Attachment of fibroblasts to the extracellular matrix

DAY 5-Cell proliferation and differentiation of chrondroblasts

DAY 7-Chondrocytes with synthesis and secretion of matrix

DAY 10-12-Vascular invasion, bone formation and mineralization

DAY 21-Marrow is observed.

XENOGRAFTS

Xenografts are bone grafts obtained from a species other than the host species

Sources of Xenograft →

- Bovine
- Equine
- Porcine
- Coralline

OSTEOCONDUCTION

BOVINE XENOGRAFTS

Deproteinized

Because of the antigenic property of Bovine Bone

By extracting out all possible organic content from the graft using ***ETHYLENEDIAMINE,*** prevent graft rejection

Demineralized

Protein obtained from bone by demineralization process, has been used as a scaffold and for tissue engineering in bone repairing

ANORGANIC BOVINE BONE(ABB)

Remove all organic components (bovine bone)

↓

Leaving behind a non-organic bone matrix in an unchanged inorganic form.

Commercially Available

- **Bio-OssR**
- **Bio-Oss Collagen R**
- **OsteoGraf**
- **PepGen P-15R**

Commercially available Bovine Grafts

Osteo-Graf

Pep-Gen p-15

Porcine Xenografts

Derived from Porcine CORTICAL & CANCELLOUS bone.

It is a particulated, high-porosity corticocancellous xenograft.

THERMAL PROCESSING OF PORCINE GRAFT HAS TO BE DONE

To eliminate pathogenic elements

To maintain structure & composition of the natural collagen & Hydroxyapatite

Equine Xenografts

ENZYMATIC DEGRADATION of equine grafts has to be done

- **To remove the antigenic property**
- **To preserve the Type I collagen**

TYPE I COLLAGEN → **Type I collagen activates both osteoblast and osteoclast adhesion and differentiation, as well as growth factor release.**

COMMERCIALLY AVAILABLE EQUINE XENOGRAFTS

Kim et al 2010 -Assessed periodontal regenerative capacity of equine particulate bone in canine alveolar bone defects where it showed significant differences in probing depth new cementum length ,newly formed bone area and bone volume fraction values when compared to negative control and collagen membranes.

Coralline Xenografts

The porous microstructure of marine coral has also been used as a template to fabricate porous coralline HA materials.

Structural features of commercially used coral are similar to that of cancellous bone,which makes them as a suitable bone substitute.

Bio Compatible

osteoconductive potential

Pore size: 100-200 µm

They possess ~45% porosity that allows for greater resorption and new bone infiltration

COMMERCIALLY AVAILABLE CORALLINE XENOGRAFTS

ALLOPLASTS

Alloplasts are inert synthetic graft material

- **Commonly used alloplast materials are**

Calcium carbonate	Calcium sulfate	Bioactive glass polymers
Ceramic materials	Synthetic hydroxyapatite	Tricalcium phosphate (TCP)

STRICTLY OSTEOCONDUCTIVE

Properties of alloplasts:

- **Biocompatible**
- **Able to withstand**
- **Resorbable and replaceable by bone**
- **Sufficiently porous**
- **Non carcinogenic**
- **Non inflammatory**
- **Non antigenic**

1.HYDROXYAPETITE

- It is the basic inorganic component of bone.
- HA ceramics have the stoichiometry similar to that of natural bone.

FORMS OF HYDROXYAPETITE

- Depending upon the method of procurement & processing,,,,

- Polycrystalline Ceramic form of HA
- Coralline porous non-resorbable HA
- Resorbable non ceramic form of HA
- Nanocrystalline HA
- Fluorohydroxyapatite

Polycrystalline Ceramic form of HA

- **Have relatively large particle size**

OSTEOGRAF D-300 — **Particle size-250-420 µm**

CALCITITE — **Particle size-420-840 µm**

Dense hydroxyapatite grafts are osteophilic and osteoconductive, and act primarily as inert biocompatible fillers

Coralline porous non-resorbable HA

- **Derived from Marine coral skeleton**

Fluorohydroxyapatite

- **Derived from calcifying marine algae**
- **Particle size-25-35 nm**
- **Commercially available as**

FRIOS ALGIPORE

TRICALCIUM PHOSPHATE(TCP)

- Tricalcium phosphate is a porous form of calcium phosphate.
- commonly used form is β-tricalcium phosphate.
- TCP induce osteoconduction of bone into the defect followed by the resorption of the β-tricalcium phosphate scaffold so that no biomaterial is permanenatly left within the reconstruction site.

•Commercially available as : Cerasorb

CALCIUM PHOSPHATE

- **Highly bio-compatible & Osteoconductive.**
- **Can be used as a carrier for drugs & growth factors to promote bone formation.**

Calcibon,Augmentech

BIO-ACTIVE GLASS

Bioactive glass is a hard, solid, transparent material composed of sodium oxide, calcium oxide, phosphorus pentoxide, and silicon dioxide, with silicate as the primary component.

Bioactive glass is not replaced by bone, but a strong molecular bond does form between its surface and bone without an intervening layer of fibrous tissue.

Bio active glass has composite organic-inorganic interface with bone followed by implantation into the defect

Responsible for the mechanically and chemically strong bond between bioactive glass and bone

Particles – contact – tissue fluids

↓

It become coated with hydrocarbonate apatite

↓

Incorporates organic protein (Chondroitin sulfate, Glycosaminoglycans)

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Attracts osteoblasts

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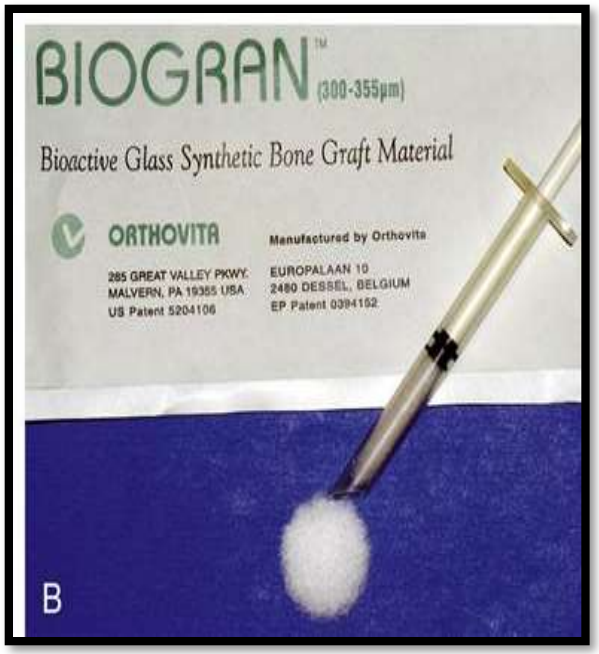
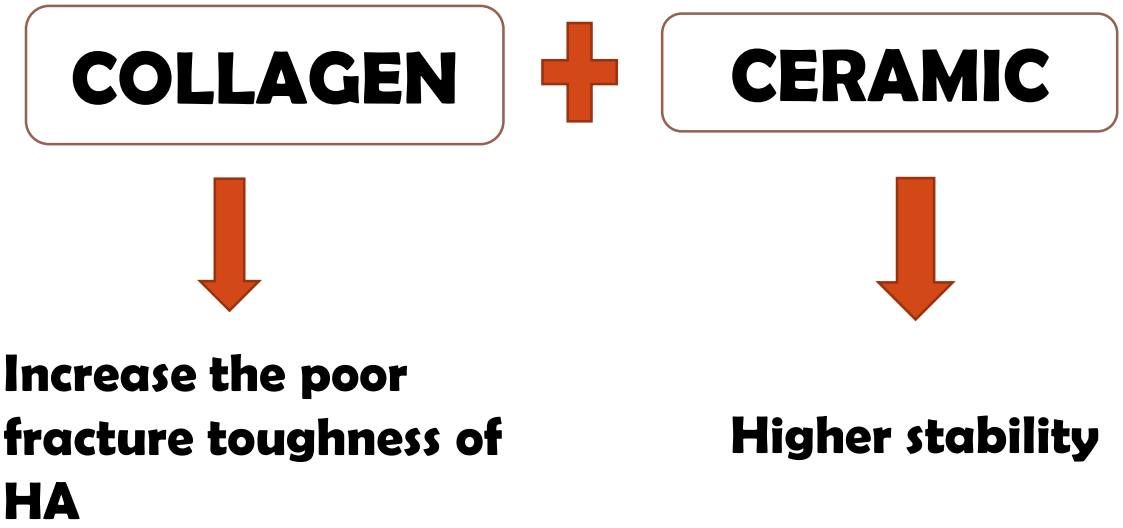
Rapidly forms bone (Andreeg et al)

Commercially available



COMPOSITE GRAFTS

Composite grafts can be defined as any combination of materials that includes both an osteoconductive matrix and an osteogenic or osteoinductive material



Commercially available composite grafts

Factors influencing healing of grafts

LOCAL FACTORS

Absence of infection	Soft tissue closure	Defect size & Topography
Space maintenance	Healing Time	Graft Immobilization
Blood supply to graft	Growth Factors	Particle size

SYSTEMIC FACTORS

SYSTEMIC CONDITIONS

Diabetes,
Hyperparathyroidism,
Thyrotoxicosis,
Osteomalacia,
Osteoporosis,
Paget's disease,

HABITS

Smoking
Alcohol

Evaluation of graft success for periodontal regeneration

- Histological Methods
- Clinical method
- Radiographic method
- surgical reenrty

Evidence supporting placement of bone graft

Van Meekren 1682,Von Walter et Al 1882,Ollier et Al 1867,Urist 1953

- Stable blood clot
- Increases in cell migration
- Enhanced bone fill

Evidence that does not support placement of graft:

Mellonig et al in 1899,Dragoo Et Al 1890,Bowers et al 1952

- Little evidences of bone formation in human
- New bone formation even without bone grafts
- Death of graft cells evident after graft placement

Systematic reviews

•Sculean et al (2015) - In a systematic review on biomaterials for promoting regeneration in human intrabony defects concluded that percentage of treated defects were 80% with histologic evidence of regeneration among biomaterials group.

•Yun chun Wu et al (2017) - periodontal regeneration therapies compaed to flap seemed to be maintained upto 5-10 years in terms of PPD reduction and CAL gain (META ANALYSIS)