Bone Grafting and Implant Dentistry Update

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Objectives

- Understand the evolution of bone grafting techniques and materials
- Identify the different types of bone grafts, their characteristics, and the benefits/risks of each
- Overview of the latest trends in implant hardware and the technology for diagnosis and planning
My Background

- B.A. History - UCLA
- Teaching Credential Program - CSU Dominguez Hills
- D.D.S. - University of the Pacific, AAD SOD
- 18 years private practice
- 3 years with J. Morita USA
- Member ADA, CDA, OCDS, AO, IADMFR
- “Family” of dentists
Motivation
What is a Bone Graft?

Historically, bone grafting has consisted of:

- A surgical procedure to harvest the patient's own bone from a secondary site
- Utilization of an organic or artificial material to replace missing bone
1668- Dutch Surgeon, Job Janszoon van Meekeren:

- Described the use of canine bone to repair a cranial wound
- Who did it?
- Did it work?
- Russian church
- The “amazing” Dr. Van Meekeren???

Thanks, destructive nature of warfare in the 20th century
Bone Grafting Today

- Surpassed only by blood transfusions as the most transplanted human tissue
- 7-10 days of antibiotic coverage is routine with all bone grafting techniques
- Bone grafting has become a very hot dental topic
Bone grafting applications

- Socket preservation
- Periodontal defects
- Third molar extraction sites to support 2\textsuperscript{nd} molars
- Ridge augmentation
- Defects following cyst removal / apicoectomies
- Sinus lifts
- Distraction osteogenesis
- Nerve repositioning
- IMPLANT DENTISTRY!!!
Why Preserve the Alveolar Ridge?

Bone loss is continuous and inevitable

Chewing pressure from roots or implants stimulate bone cells

Alveolar bone in edentulous areas resorbs 0.5 to 1 mm per year
Why Preserve the Alveolar Ridge?

Dr. Jon Suzuki, Director Post-Graduate Periodontics at Temple University:

“…placing some type of graft material in the socket following every extraction is rapidly approaching standard of care status.”
Most bone graft materials fall into two main categories:

**Osteoconductive:**
A framework for new bone to grow into at its normal healing rate.

**Osteoinductive:****
Stimulate bone to grow at an advanced rate. Most have added ingredients, (Growth Factors or Bone Morphogenetic Proteins).
Types of Bone Grafts

- Autografts
- Allografts
- Xenografts
- Synthetics
Autografts

- Also referred to as “autogenous” or “autologous” grafts.

- Source: patient’s own bone, usually harvested from their palate, hip, chin, or pelvic crest.

- “Gold Standard”
Autografts

**Pros:** contain living elements for bone growth, no risk of rejection

**Cons:** requires a second surgery, not recommended for patients with low bone density
Allografts

- Human bone, usually harvested from cadavers.
- Risk of morbidity and mortality due to poorly screened sources.
- April, 2008: California DPH required a separate license if a dental office stores an allograft for more than 24 hours.
- Commercially available allografts:
  - DFDB by Biomet
  - Puros by Zimmer Dental
Allograft examples

DFDB crystals (Biomet)        Puros block (Zimmer)
PBS- Masterpiece Theater

Alistair Cooke (1908-2004)
PBS- Monsterpiece Theater

Cookie Monster (1969-????)
The leader of a body-snatching network which stole the bones of the broadcaster Alistair Cooke and illegally plundered more than 1,400 other corpses between 2001-2005 has pleaded guilty.

Dr. Michael Mastromarino, the head of Biomedical Tissue Services, made more than $4.6 million by selling the body parts to about 20,000 transplant recipients throughout the US, Canada and Europe.

Funeral home owners in New York, Pennsylvania and New Jersey were paid $1,000 for each corpse to harvest bones, skin, arterial valves, ligaments and tendons - some of them diseased.

Mastromarino, a 44-year-old former oral surgeon, (whose license was suspended prior to running BTS), was convicted and will spend 18-54 years in prison. More than 900 civil law suits have been filed against him.
Faux bone????
Xenografts

- Bone or other tissue from animals, usually bovine or porcine

- Must be manufactured in a specific manner to ensure sterility and biocompatibility

- Most materials act as a “scaffold” for new bone to grow into at its normal rate.

Some examples include:

- **BioOss** by Osteohealth
- **PepGen15** by Dentsply
Xenograft examples

Bio-Oss (Geistlich)

Powder (minerals of bovine bone) and sterile saline
Xenograft examples
PepGen P15 (Dentsply)

**Powder** (Collagen, Bovine minerals & synthetic analog of a peptide chain)

**Liquid** (Sterile saline)
Synthetic (Alloplast) Materials

- Alternative materials to avoid the drawbacks of autografts or allografts
- Examples include coral and TCP
- Very little risk of morbidity or mortality
- Some are non-resorbable and act as replacement bone
- Others are resorbable frameworks or scaffolds for bone to grow into at its normal rate
- Some commercially available products are: 
  - **Bioplant** by Kerr Dental
  - **Gem 21S** by Osteohealth.
Examples of Alloplasts

Bioplant (Kerr)  Polymethyl MA + Polyhydroxyethyl MA

Gem 21S (Osteohealth)  rh-PDGF solution (Platelet Derived Growth Factor)  B-TCP granules
BMP’s and Growth Factors

Bone Morphogenetic Proteins:

- Discovered 1965 – Dr. Marshall Urist UCLA
- Found in human blood and bones that stimulate osteoinduction
- 20 have been identified, 2 have FDA approval for use in bone grafting (2 & 7)
- Extracted from human tissue or fabricated in the lab
- Interact with receptors on surface of bone cells
- Expensive, but stimulate bone to grow faster
- Suspicion of carcinogenicity? (June 2008 Journal of American Academy of Orthopaedic Surgeons)
BMP’s and Growth Factors

Products containing BMPs:

- **Infuse**: (Medtronics Corporation)
- **OP-1**: (Stryker Biotech)
- **Accel Connexus**: (IsoTis Orthobiologics)
- **Accel DBM 100**: (IsoTis Orthobiologics)
- **Grafton DBM**: (BioHorizons)
- **Regenafil**: (Exactech)
BMP’s and Growth Factors

Platelet-derived growth factor (PDGF):

- One of numerous proteins regulating cell growth and division
- Role in embryonic development, cell proliferation, cell migration
- Stimulates bone to grow faster
PRP
Platelet Rich Plasma Centrifuge Technique

Platelet functions:

- Hemostasis
- Scaffold for tissue regeneration
- Increase level of GF’s
- Attract stem cells
Barrier Membranes
Are there other grafting options?

YES!!!

Collagen-based products are also now available.
FOUNDATION™
Collagen-Based Bone Filling Augmentation Material for Use in the Filling of Extraction Sockets
What is Collagen?

- Insoluble, extra-cellular protein found in all animals
- Most abundant protein in the human body
- Essential component of all connective tissues such as cartilage, bone, tendons, ligaments, and skin
The History of Foundation

Terudermis
(approved in Japan 1993-skin grafting)

Teruplug
(approved in Japan 1997-dental)

Terumo Medical Corporation, Tokyo, Japan
“FOUNDATION is a collagen-based bone filling augmentation material for use in the filling of extraction sockets” (2004)

**Manufactured** - Terumo Corp.- Japan, (now Olympus-Terumo Biomaterials)

**Approved** - Japanese Ministry of Health as “Teruplug” - July 1997  
FDA as “Foundation” - October 2004

**Launched** - “Foundation” in U.S. Market by J. Morita USA- February 2006
There are five published studies done in Japan by the following institutions:

- Nihon University School of Dentistry at Matsudo
- Kanagawa Dental College, Department of Periodontology
- School of Medicine, Yokohama City University, Dept. of OMFS
- Osaka Dental University
- Terumo Corporation

There is another study currently in progress at the University of Rochester.
Foundation’s Manufacturing Process

1. **Bovine collagen - Type III (skin only)**
   - Telopeptide (this protein acts as an antigen in a different species)
   - Protease (pepsin) treatment to remove telopeptides (pH 3)

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"Atelo-collagen"
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2. **Neutralized (pH 7)**
   - Neutralized atelo-collagen
   - Fibrillar atelo-collagen
     - Scaffold for surrounding cells

3. **Heated over 37°C/100 °F**
   - Heat-denatured atelo-collagen
     - Stimulates infiltration of cells into the scaffold
Fibrillar atelo-collagen (scaffold) + Heat-denatured atelo-collagen

Cross-linked by heat and formed into a bullet shape

S size 8 mm 15 mm
M size 25 mm
How Does “Heat Denatured” Atelocollagen stimulate bone to grow?

- HAC has an inherent quality called “chemotaxis”

- “A response of motile cells where the direction of movement is affected by the gradient of a diffusible substance”

- The HAC creates a chemical stimulus that causes bone growth cells to be drawn into the plug at a rapid pace

- Only product on the market that speeds up the healing process without BMPs or PDGFs
Why Bovine Collagen?

- Abundant supply
- Highly compatible with alveolar bone
- Attracts fibroblasts and osteoblasts which accelerate new bone formation
Hypersensitivity to Bovine Collagen

Japan:
October 1998- March 2005, over 450,000 units sold
Three cases of “rash” have been reported from users.

U.S.A./Canada:
February 2006- present
No cases reported
Safety Precautions for Prevention of BSE Exposure (Bovine Spongiform Encephalopathy), or Mad Cow Disease

- All documented cases of BSE have been in animals older than 12 months. All bovines used for FOUNDATION are less than 6 months old.

- Only skin is extracted from the bovine.

- 99% of cases have been in Europe.

- European Medical Examination Agency (EMEA) classifies each organ into 4 risk categories for potential BSE infection, “High”, “Middle”, “Low”, and “No risk”. Skin is defined as “No risk”.

- The FDA and the U.S. Dept. of Agriculture (USDA) also state that skin-derived bovine products present “No risk” for BSE.
Foundation Safety During Manufacturing

Sterility Assurance Level (SAL):

- Estimates the probability of any medical device being non-sterile after sterilization.

- Foundation is dry-heat sterilized (3X) to a SAL of 10(-6), or a 1 in 1 million chance on non-sterility prior to packaging.

- Same SAL as sterile surgical gloves.
Foundation vs. Collaplug
Confusion, but no comparison

**Collaplug** (Zimmer Dental)
- Bovine collagen
- Bullet shaped plug
- “Wound healer” only
- Used in combination with other products

**Foundation**
- Bovine collagen
- Bullet shaped plug
- No membrane
- Accelerates bone growth
- Maintains alveolar ridge
- Implants placed as sooner
1. Tooth Extraction

2. Extraction socket is created and bone is exposed.

3. Insertion of FOUNDATION

4. The socket is filled with FOUNDATION and it also covers the extraction surface.

5. Surrounding cells and capillaries infiltrate into FOUNDATION. Peripheral gingiva extends onto it.

6. The extraction socket closes and is filled with augmented bone.
The Basics for using Foundation

Photos Courtesy of Dr. Edward Marcus
Yardley, PA
“Tooth” #12
Beginning the extraction
Atraumatic root tip removal
Proper handling of Foundation
Small size Foundation
Shaping the plug
Plug now mimics shape of root tip
Extraction of intact root tip
Curetting the socket
Inserting the plug
Further.....
Further...
Foundation in place
Gentle condensation of the plug
Compression of buccal and lingual plates
Done, ready for passive suture
2 weeks post-op healing
4 weeks post-op healing
12 weeks post-op healing
Implant placement- 12 weeks post-op
Implant in place - 12 weeks post-op
Digital panoramic survey - 12 weeks post-op
Indications for Use

The following cases demonstrate the use of Foundation in strict adherence to the FDA-approved “Indications for Use” guidelines.
Extraction of #8 due to advanced perio disease in a 65 year old female

Before extraction

Immediately after extraction

Application of FOUNDATION

Sutured
Pre-op / Post-op
Oro-antral fistula (58 year-old male)

Tooth extraction

Application of FOUNDATION

1 week later

2 weeks later
Routine extraction in a diabetic patient

Tooth extraction

3 days later

Application of FOUNDATION

1 week later

2 weeks later
FAILURE CASE
Extraction Sockets by Marginal Periodontitis
(78 year-old male)

Immediate post-op, socket not well curetted

Four days post-op
Health Canada issued license #71546 on June 7, 2006 for Foundation as follows:

“A collagen based bone filling material”
Missing teeth

Pre-Op

Full-thickness flap

Decorticating the bone

Application of FOUNDATION
Pre-Op

Membrane placed

Suture placed

Pre-Op

3 months Post-Op
Pre-Op
(3mm wide)

3 months Post-Op
(6mm wide)
Foundation viewed by J. Morita Accuitomo
3D Imaging demonstrating bone growth

Day of extraction

12 weeks post-op
Keys to Success

1. Curette the socket and remove any unhealthy tissue to expose bone.

2. Place FOUNDATION in the socket using forceps or clean gloves.

3. FOUNDATION must be saturated with blood.

4. Select a slightly larger size of FOUNDATION than the socket to be filled. FOUNDATION must be in contact with bone to stimulate new growth.

5. If a bony wall is missing make sure FOUNDATION is firmly supporting the soft tissue in that area.

6. Secure FOUNDATION by suturing to prevent its dislodgement from the extraction socket. Primary closure is not required.
What others are saying:

- Gordon Christiansen, (Clinical Research Associates) reported a “96% Clinical Success Rate” in their September 2007 CRA Newsletter

- Dr. Joe Blaes, Editor of *Dental Economics* wrote an article in the July 2007 issue called “From Footings to Finishes” in his “Pearls for your Practice” column

- Foundation was named as a "Top 100 Product" by *Dentistry Today* in 2007 and 2008
ROI- A Win / Win for you and your patient

- Preserves ridge/socket after any permanent tooth extraction
- 3rd molars
- Higher level of patient care
- Increase production
Insurance Code- U.S.

ADA–CDT Code #7953: “Ridge Preservation Bone Graft”
Insurance Code- Canada

72431- Alveolar Bone Preservation- Xenograft (first socket)

72439- Alveolar Bone Preservation- Xenograft (each additional socket)

* As per Dr. Jim Gray, Director Member Services- BC Dental Association
Summary

- Bone grafting for socket/ridge preservation has become a key part of the exploding practice of implant dentistry.

- Older grafting techniques and materials are no less successful.

- New materials are making the process more efficient without sacrificing any of the predictability of the past.

- Socket/ridge preservation will soon become a routine procedure not only for the specialist, but also for the general practitioner.
Osseointegration

Osteoblast

Titanium

SEM
Implant Dentistry

Edentulism

- Primary Etiology?
- U.S. stats:
  - 20M totally edentulous
  - 15M edentulous in one arch
  - 100M partially edentulous

Kalorama Information, 2005
2004 BRFSS* study on Edentulous Seniors (65+), Rhode Island

- Female
- Minority
- High school diploma or less
- Low income
- Single
- Renter
- Urban dweller

*Behavioral Risk Factor Surveillance System- A component of the CDC
Implant Dentistry

Other characteristics (Edentulous 65+):

- Don’t exercise
- Overweight
- Smoker
- Regular alcohol use
- No regular dental or medical visits
- Physically or mentally unhealthy
- Depressed or anxious
- Poor sleep
- No energy
Implant Dentistry

Patients with no dental insurance:

- Elderly
- Minority
- High school diploma or less
- Low income
- Unemployed or retired
- Also has no health insurance
Implant Dentistry

Yet....

People are living longer and developments in bone grafting and implant techniques are providing better options for the edentulous and the partially edentulous
Implant Dentistry

- “Big Four”
  *Nobel Biocare, Straumann, Biomet 3i, Zimmer*

- 2006 = 73.7%
- 2007 = 70.1%

- 100+ implant companies worldwide

Why???
Per Ingvar Branemark

- 1952- Titanium implants in rabbits
- Swedish orthopaedic surgeon- initially focused on knee and hip applications
- High rate of edentulism changed his focus
- 1965- Gosta Larrson
- Partnership with “Bofors AB”—Nobelpharma—Nobel Biocare
- “Osseointegration”
Dr. Leonard Linkow

Blade implants, implantologist to the “stars”??
Dr. Gerald Niznick

- Paragon/Core-Vent from 1982-2001
- Sold to Sulzer 2001 (later acquired by Zimmer) for $102M
- Agreed to a 5 year “Non-compete” clause
- Started Implant Direct LLC with 7 new patents
Osseoperception as per P.I. Branemark

- Osseointegration: A living process
  
- Fixtures are connected to a prosthesis and forces are transmitted to surrounding bone
  
- The fixture becomes part of the body and the mind
  
- Prosthetics somehow communicate with the brain to restore function
Osseoperception
Original Branemark System
Implant Dentistry

- Traditional implant systems

  - Crown
  - Abutment
  - Fixture
Implant Dentistry

- **BICON**
- **Straumann**
  - SLActive
- **3i**
- **Nobel Active**
- **Nobel Active**
- **Zimmer One piece**
- **NanoTite Ca Ph coated**
Implant Dentistry

- **Straumann SLActive:**
  - Sandblasted with **Large** grit followed by **Acid** etching, then conditioned in **nitrogen** and preserved in saline. Surface becomes hydrophilic, attracting blood and proteins, potentially promoting faster osseointegration.

- **3i NanoTite:**
  - High energy beams bombard HA coated target, creating a molecular cloud which bonds to implant. The implant is then coated with Ca Ph for enhanced integration.

- The “first” implant?
Implant Dentistry

SYBRON Endopore

Zirconium

Titanium

BICON

6.0 x 5.7 mm
Uncoated
260-160-357

6.0 x 5.7 mm
NanoTite™
260-260-357

6.0 x 5.7 mm
HA Coated
260-360-357
Coated Implants

HA + Plasma coated

HA coated

Simpler Implants
Overdentures
Overdentures

- Metal Housing
- O-ring
- Mini Implant

Denture
Overdentures
Implant Trends

- Market shift? (cost vs. big name)
- Traditional C&B vs. single tooth implant
- Dx and Tx Planning Standard of Care
- Endodontists (2008 AAE meeting)
- GP’s vs. specialists
- Delayed placement vs. Immediate placement vs. Immediate load
- Roughened surface preferred over coating
- Dental Tourism

(272,000 medical & dental “tourists” spent $656 million in India in 2007. This total is expected to hit $2.5 billion by 2012.)
OMFR is a specialty

Only about 80 OMFRs in the U.S.

Only 5 programs (Iowa, Conn, UMKC, SA, UNC)

Opportunities???
Digital Imaging

According to Dentalcompare.com:

- 20 percent to 35 percent of dentists have incorporated digital x-ray systems
- Majority are general dentists
- Digital radiography is fast becoming the standard of care for diagnostic imaging in dentistry
DICOM (Digital Imaging and Communications in Medicine) is a standardized format for handling, storing, printing, and transmitting information in medical imaging.

DICOM standards are developed by American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA).

DICOM enables the integration of scanners, servers, workstations, printers, and network hardware from multiple manufacturers into an archiving and communication system.
Digital Imaging

Digital panoramic x-ray units are the fastest growing capital equipment market in the world

2006 compared to 2007:
- Digital pan sales grew by 27%
- Film based pan sales dropped by 49%
- Digital-Film based sales ratio went from 6-1 to 14-1

WHY???
Digital Imaging

- Higher resolution
- **Lower dosage** (as much as 80-90%)
- **As Low As Reasonably Achievable**
- Electronic claims
- Better patient communication, case acceptance
- Elimination of poor images
- Environmentally responsible (No chemical disposal)
Digital Imaging

Causes of poor images with Film-based systems:

- Patient movement
- Improper Kv or mA settings
- Poor patient positioning

DARKROOM ISSUES (80% of problems)
3D Cone Beam CT Imaging
3D Cone Beam CT Imaging

- A radiograph is a 2D representation of a 3D object
- That 3rd dimension is what radiologists/clinicians have been searching for
The Changing World of 3D Imaging

- *Linear tomography* - mid 1930s
- Comput*ed Tomography (CT)* - 1970’s
- *Cone Beam CT (CBCT)* - late 20th Century
The Changing World of 3D Imaging

Linear Tomography

Computed Tomography

Cone Beam CT
Cone Beam CT vs. Medical CT

- Cost of CBCT scan is much less than medical CT
- The equipment is substantially lighter and smaller.
- CBCTs have better image resolution (smaller pixels)
- Very easy to operate and to maintain; little technician training is required
- Some cone beam manufacturers are dedicated to the dental market
Cone Beam CT vs. Medical CT

- In CBCT patient is seated, as compared with lying down in a medical CT unit
- Open design of the cone beam CT units virtually eliminates claustrophobia
- The upright position is also thought to provide a more realistic picture of condylar positions during a TMJ exam
- Radiation dose is considerably less than a medical CT
Computed Tomography (CT) - 1970’s
Cone Beam CT (CBCT)- late 20th century
Medical CT vs CBCT

Medical CT
- X-ray Source
- Row of X-ray Detectors
- 2D (pixel) Reconstruction
- 2D reconstruction

CBCT
- X-ray Source
- Flat panel X-ray Detector
- Cone Beam reconstruction
- 3D (Voxel) Reconstruction
Voxel?

“volume” and “pixel”
3D Cone Beam CT Imaging

Applications:

- Implant planning (Now the S.O.C.???)
- Endo- as per Steve Buchanan
- Identifying pathology
- TMJ
- ENT
- Ortho evaluation
- Pre/Intra/Post-Op assessment of trauma
- Locating foreign bodies
- Cleft lip/palate
- Caries detection
3D Accuitomo 80

**Imaging Areas**

40mm φ x 40mm H

60mm φ x 60mm H

80mm φ x 80mm H

**Voxel Sizes**

80μm

125μm

160μm
Field of View

- **Φ40×H40mm**
  - Small Area

- **Φ40×H80mm**
  - Full view of Antagonistic Teeth

- **Φ80×H80mm**
  - Full Mouth
FOV

- Field Of View
- How big is too big?
- Liability
Implant Tx Planning Systems

Materialise (Simplant)

- world's first interactive 3D Implant Planning System 1998
- precise preoperative planning software
- allows clinician to find the ideal position of the implants
- compatible with every implant brand

After vital structures are located, the “SurgiGuide” is fabricated to drill exactly to the planned implant location.
Implant Tx Planning Systems

NobelGuide

- Introduced 2005
- Only works with NB implants
- Uses “Procera” software
Materialise vs. Nobel Biocare

- **June 1998** – Materialise is awarded a U.S. Patent
- **August 1998** – Materialise is awarded a European Patent
- **June 2005** – Nobel Biocare launches its NobelGuide product in Germany.
- **November 2006** – Materialise files a patent infringement action in Germany
- **June 25 2005** - Nobel Biocare files a nullify action in Germany
- **August 2007** – Nobel Biocare files civil action in California seeking a declaration of patent non-infringement
- **August 2007** – German court rules that Nobel Biocare is indeed infringing on Materialise’s European patent
- **September 2007** – Nobel Biocare files an appeal against the decision of the District Court of Düsseldorf with the Düsseldorf Court of Appeals (pending)
- **October 2007** – Materialise files a counterclaim for U.S. patent infringement in California
“The Main Event”
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