Lecture 1

- Implant = substance/object that is put in the body as a prosthesis, or for treatment or diagnosis
    - A metal device placed into or on top of the jaw bone to provide support and/or retention for a dental restoration or prosthesis
        - Types
            - Subperiossteal – on top of bone but beneath tissue, not used anymore
            - Transosseous/transmandibular staple – through mandible
            - Endosseous – current type implants, screw and cement type
            - Transitional – mini implants
- Osseointegration – direct structural and functional connection between ordered, living bone and the surface of a load carrying implant
- Fibro-osseous integration – fibro-osseous ligament, usually means implant failure from soft tissue intervention

Implant Types

- Implants – Branemark system (screw retained) – 5 component system
    - Gold screw → gold cylinder, abutment screw → abutment → fixture
        - Gold cylinder attaches onto the abutment screw
- Implants – Cement retained system – 3 component system
    - Crown cemented on top of abutment
    - Abutment connected via abutment screw (inside) to implant

Restorative sequencing

- Prosthodontics consult (Treatment planning, diagnosis)
    - Imaging – CT, panoramic
  - Diagnosis – partially edentulous, cause?
  - Med and Dent Hx
    - Contraindications = bone disorders, poorly controlled diabetes, heavy smoking
      - Smoking has no effect on posterior Mn implant prognosis
  - Bone quality, quantity (need imaging)
    - Quality – D1, D2, D3, D4
  - Intraoral exam
    - BL dimension, MD dimension
    - Vertical space
    - Guidance, bruxism, periodontal diagnosis on adjacent teeth (bacteria may block implant healing)
  - Tx options, time line, costs (need imaging – see if patient needs sinus lift)
    - Implant, FPD, RPD, do nothing
    - Esthetic expectations, upper lip smile line
    - Longevity
      - Bridge – 74% last 15 years, adjacent teeth last 92% at 10 years
        - Loss of 8-18% of adjacent teeth over 10 years
      - Implant – 95% last 8-20 years, adjacent teeth last 99.5% at 10 years
      - RPD – 50% last 10 years, adjacent teeth last 56% at 10 years
  - Tx sequences (need imaging)
  - Preliminary impressions
    - Study and communicate with surgeon, fabricate interim RPD, fabricate surgical guide
- Surgical consultation
  - Bone grafting, if needed, may take 3-6 months
  - Direct sinus lift – flap opened side of Mx, pack bone (can pack lots)
  - Indirect sinus lift – osteotome technique, implant placed immediately
    - More than 54.2% of Mx posterior implants involved sinus augmentation
- Surgical guide fabrication – use diagnostic cast, get location and angle of implant placement
- 1st stage surgery – place implant on bone, place cover screw
  - Integration takes 3-6 months
- 2nd stage surgery – remove tissue and cover screws, place healing abutments
  - Soft tissue healing takes 2-3 weeks
- Impression
- Final restoration delivery

Lecture 2

Evaluation of Implants

- Implant success – highest in anterior Mn, lowest in posterior Mx
  - Immobile
  - No radiolucency
  - <0.2mm/year loss, first year loss <1.0mm
  - No persistent pain, discomfort, or infection attributed to implant
    - Determine if pain is from bone or from soft tissue being impinged on (dull pain = from bone)
  - Implant design doesn't preclude prosthesis placement, appearance satisfactory to patient and dentist

Spacing

- 1.5mm between implant and natural tooth/implant and labial/lingual bone
  - Prefer 2.0mm of labial bone to retain gingival height – avoid recession with crown margin exposure
- 3.0mm between 2 implants
  - Natural tooth has PDL, bone does not have good vascularization – need adequate blood supply
- 2.0-3.0mm depth between top of implant and CEJ of adjacent natural teeth
  - Emergence profile
  - Bigger discrepancy between implant and natural tooth diameter = deeper implant should be
- Ferrule – 2.0mm high, 1.0mm thick
- 4.0-5.0mm gutta percha seal needed at apical
- For radiographs, can see distortion if you can't see implant threads
  - Harder to see distortion in edentulous areas

Surgical Plans

  - Want to get initial stability and long term implant success
- Conventional implant placement
  - Extraction site healing (2-4 months) before implant surgery
  - 1^{st} and 2^{nd} stage surgeries needed
  - Healing period between surgical stages 3-6 months, removable prosthesis used by patient
  - Impression taken 2-3 weeks after 2^{nd} stage surgery for master cast
- Immediate implant placement
  - Placing implant after extraction of NON-infected tooth (shortens total time by 2-4 months)
  - Need regular crown/root ratio, do not load immediately (prevent soft tissue intervention)
- One stage implant
  - Placed in jaw and remain exposed (eliminate 2^{nd} stage surgery)
  - If there are any doubts in healing process = use 2 stage surgery
- Immediate restoration
  - Immediate implant placement with immediate restoration can be planned to maintain and support periodontal tissue as much as possible to get maximum esthetics
  - Eliminate all centric and eccentric contacts
- Immediate loading
  - If bone quality is good enough, should withstand loading without critical micromotion and still achieve osseointegration
  - Mainly anterior Mn, multiple implants splinted together, fabricated interim for healing periods before definitive restoration is constructed

Radiographs

- Periapicals (14% distortion)
  - No cross sectional information
  - Distortion/magnification (Technique dependent)
    - Only 53% of measurements from crest to canal are accurate to 1mm
- Panoramic (23% distortion)
  - No cross sectional information
  - Varies from machine to machine and area to area
    - Variable inherent magnification/distortion of 20-30%, horizontal more variable than vertical
      - Take length of measurement and decrease by 20-30% to be safe
    - Only 17% of measurements from crest to canal are accurate to 1mm
- CT (1.8% distortion)
  - Cross sectional imaging
  - Assess bone density (HU) – water density = 0 (benchmark), increased value = increased density
  - Implant software, 3D representations
  - Uniform and minimal magnification with CT
    - 94% of measurements from crest to canal accurate to 1mm

Treatment Sequence – single implant restoration

- Prosthodontics consult
  - Imaging
- Surgical consult
  - Medical history
  - Bone level – requires imaging
  - Surgical plan – immediate placement, one stage implant, sinus lift, etc – requires imaging
  - IV sedation confirmation
    - Medical history
    - Nothing to eat or drink (not even water) 6-8h before surgery
    - Require guardian for travel TO AND FROM surgery
    - Use restroom immediately before sedation (clear the bladder)
  - Sequences, timeline, fees
  - Consent form
  - Instructions – NPO, designated driver, premedication, etc
- Surgical guide/radiographic guide fabrication
  - Diagnostic casts with diagnostic wax up – locate most ideal place to position missing teeth
    - For fully edentulous case, need duplicate of existing denture or full arch denture teeth with wax try in to confirm tooth set up is ideal
  - After locating most ideal tooth position, make radiographic guide – template to indicate location of implant osteotomies during radiography
  - Do imaging, determine if there is a need to change implant position. Fabricate surgical guide
    - May need to trim the surgical guide flange so surgeon can see where bone is
- 1^{st} stage surgery, 2^{nd} stage surgery
- Impression
- Final restoration delivery
- Maintenance

Lecture 3

Grafting Techniques

- Increasing thickness
  - Particulate bone
  - Block graft
  - Ridge split with chisel/osteotome
  - Greenstick fracture
- Increasing height
  - Block graft
  - Sinus lift – direct/indirect
  - Distraction osteogenesis
  - Mn nerve transposition

Graft Materials

- Autograft – self bone
- Allograft – same species
- Xenograft – different species (usually bovine)
- Alloplast – synthetic

- Osteoconductive – particulate bone
  - Guides bone growth
- Osteoinductive – human rich plasma added to facilitate human bone growth added to scaffold
  - Biocompatible, causes laying down of new bone, promotes new bone growth

Healing Times

- Bone Graft – 2-4 months
- Implant – 3-6 months
- Tissue – 2-4 weeks

Lecture 4

Requirements for Successful Implants

- Recognition of patient's CC
- Medical risk assessment
- Evaluation of
  - Ridge morphology
  - Bone quality
  - Relation of edentulous areas to opposing arch/teeth/prosthesis
  - Periodontal status
  - Restorability of natural dentition
- Effect of patient's habits – smoking, bruxism
- Organized treatment plan – procedures, costs and time, sequencing with time intervals between each step
- Maintenance, including recall intervals

Siebert Classification of Ridge Deficiencies

- I – buccal/lingual deficiency (best case for ridge deficiency)
- II – apical/coronal deficiency
- III – both I and II

Site Selection for Implants

- 7mm diameter – 4mm for implant diameter, 1.5mm either side of implant (for single implants)
  - Prefer 2mm of labial bone
- Dentinal gingival fibers – provide support for gingival tissues in natural teeth
  - Periodontal healthy anterior tooth = 5.5mm papilla height coronal to interproximal alveolar bone crest
  - Implants lack these fibers – height between TWO implants = 3.4mm (black triangle, short papilla)
  - Papilla morphology dependent on perio status, ridge morphology dependent on quantity/shape of bone
- Ridge reconstruction – 4 main principles
  - Residual socket walls hold bone graft in place, stabilize clot required for guided bone regeneration
  - Residual socket walls provide blood supply, maintains space
  - Thin labial walls resorb in apical and palatal direction – bone graft for ridge preservation
  - Primary closure of flaps helps exclude oral environment – enhances guided bone regeneration
- Surgical Guide
  - Helps orient position of implant, confirms marginal bone height

Effects of Edentulism

- Complete denture function is 1/4 to 1/7 that of natural dentition
- >50% Mn dentures have problems with retention and stability
  - Difficulty performing life tasks (speaking, eating) impacts quality of life
- Mean residual ridge resorbtion in Mn is 4x that of Mx (0.4mm vs 0.1mm per year)

Indications for 2 Implant Overdentures

- Already adequate lower denture, but want better retention/stability
- RPD patients who need to get rest of teeth pulled
- Age nor osteoporosis contraindication for dual implant treatment
- Treatment of choice for price and simplicity

Advantages of Implant Retained Overdentures

- Prevent bone loss
- Facial esthetics
- Improve retention/stability of prosthesis
- Improve chewing, increase occlusal force
- Create reproducible centric relation occlusion
- Improve speech, self-esteem, confidence
- Requires fewer implants than fixed restoration
- Reduces need for bone grafting compared to fixed restoration
- Requires less specific implant placement (but REQUIRES parallelism to insert prosthesis, wear of rubber O-rings)
- Acrylic flange can have better esthetics compared to fixed restoration
- Easier hygiene access, easily repaired

Mn Site Implant Placement

- Placed in canine region (Mn anterior, greatest bone height)
- Fulcrum line should run through middle of prosthesis AND be parallel to mandibular hinge access
- Implants placed vertically so tops of metal housings parallel to occlusal plane of patient's denture/opposing arch
- Placed parallel to each other (within 15^{o}) and perpendicular to occlusal plane (optimal function)

Impression Appointment

  - Check implant is ready for restoration
  - Remove healing abutments, ensure soft tissue health
  - Connect impression post, do imaging to see it is fully seated
  - Take final impression, place healing abutment back on patient
  - Routine works – facebow, shade, interocclusal record, alginate impression
- Common complications
  - Loose healing abutment – do soft tissue removal surgery
  - Excess bone around top of implant fixture – do bone reduction surgery
    - Surgeon did not image to see bone growth/ensure abutment against implant instead of bone
  - Immature soft tissue around healing abutment
    - May have bacterial growth/bad smell
  - Pain on healing abutment tightening/removal or mobile implant (implant failure)
    - Ensure no soft tissue impingement – thick abutment on thin implant post
    - Bone pain = deep, sharp pain = gingival impingement
- Implant Readiness Tests
  - Tapping – differences in pitch and decay rate of ringing sound
  - Radiograph – radiolucency, especially for clear fibro-osseous intervention (implant failure)
  - Palpation – clinical mobility (implant failure)
  - Reverse torque testing – 20Ncm is a safe, reliable method
  - Forward tightening of healing abutment – check for pain
  - Periotesting – measures contact time and movement/give – clinically should be between -8 and +10
    - -8 = good, very solid
    - +15 = really bad
  - Resonance frequency analysis

Impression Techniques

- Closed Tray – used for simple cases
- Open Tray – used for complex cases, more accurate
    - Impression posts are tied together with a scaffold and GC resin to ensure their immobility
- Implant level – healing caps removed, impression posts placed in
    - Single implant or short FPD cases, usually combined with closed tray
- Abutment level – already have fixed/detachable abutments, so impression posts placed onto these
    - Traditionally, done with open tray technique for complicated cases

- With new CAD/CAM technology (instead of casting), now use open tray with IMPLANT level for complex case

Hex Contour abutment

- Cuff height can be 1mm, 2mm, or 3mm thick
    - Determined by thickness of soft tissue
    - Lingual side margin is usually 1.5mm higher than labial side

Lecture 5

Papilla Height

- Gingival fibers
  - Interdental fibers
  - Dentogingival fibers
  - Circular fibers
  - Alveolar crest fibers
- Papilla height
  - Between implants average = 3.4mm
  - Between natural dentition average = 5.5mm
    - For natural dentition, ≤5.0mm between crest and contact point = papilla fills 100% of the time
      - 6mm = papilla present 56% of the time, >7mm = papilla present <27% of the time

Residual Bone Height

- Class A (RBH >10mm) – classical implant procedures
- Class B (RBH 7-9mm) – osteotome technique, immediate implant placement
- Class C (RBH 4-6mm) – direct sinus lift (lateral approach), immediate OR delayed implant placement
  - Bone <5mm = sinus lift, delayed implant placement
  - Bone >5mm = sinus lift, immediate implant placement
- Class D (RBH 1-3mm) – direct sinus lift, delayed implant placement

- Bicortical stabilization – elastic moduli are significantly different
  - Alveolar crest = 17.1 ± 0.72 GPa
  - Middle trabecular bone = 14.59 ± 0.72 GPa
  - Sinus floor = 17.73 ± 0.72 GPa

Bone loss

- Conventional dentures = 1.63mm/year
  - Mn CD = 0.4mm/year
  - Mx CD = 0.1mm/year
- Implant dentures = 0.69mm/year
  - 1.1% reduction/year for 2 implant overdenture
  - 1.6% increased bone loss/year for 5 implant fixed detachable

Final Restorations

- Screw retained – retrievability
- Cement retained – easy to make, less lab intensive, popular (similar to conventional crown/bridge technique)
  - Esthetic, can provide ideal centric contact location
  - Problems if screw loosens
  - Cements
    - Premier implant cements (temporary resin cements)
    - Temp bond (noneugenol, eugenol)
    - Durelon (polycarboxylate cement)
    - ZPC
    - GI cements

Final Restoration Delivery

- Remove healing abutment, ensure soft tissue health
- Connect permanent abutment via abutment screw with screw driver
- Crown try-in to verify fit for delivery today
- Connect permanent abutment with abutment screw with 30Ncm torque wrench
- PFM adjustments for proximal contacts, marginal fit, occlusion, etc
    - Place cotton ball inside screw access hole
- Cement PFM, remove excess cement
- Periapical X-ray – verify cement removal, record baseline bone height
- Post-cementation instructions
    - No PDL – centric contacts are weaker
    - Abutment screw may loosen – weaker cement used – no flossing up or down through proximal contacts
    - Overloading common cause of bone loss – no guidance/eccentric contacts
    - 6 month recalls for next 2 years – monitor bone loss/level compared to baseline

Radiographic schedule

- Pre-surgical diagnostics – PAs with CBCT or Pan
- 1st stage postop – PA (baseline)
- Healing periods – none
- 2nd stage postop – PA (healing abutment seated fully – no bone overgrowth)
- Impression appointment – PA (impression post seated fully)
- Crown cementation postop – PA (baseline, ensure excess cement removal)
- Recall appointments – PA (monitor bone level every 6months over next 36months, look for bone stability)

Implant Success

- Immobile
- No peri-implant radiolucency
- <2.0mm vertical bone loss/year
- Loss of 1.0mm in first year is expected
    - Crestal bone level usually resorbs down to first thread in first year of loading – considered normal
- No persistent pain, discomfort, infection attributed to implant
- Design does not preclude placement of prosthesis with satisfactory esthetic appearance to dentist and patient

Lecture 6

Complications of Implant Therapy

- Loss of implant anchorage
  - Early failure (before loading) – more than ½ of all failures
    - Infection
    - Improper surgical technique/poor bone quality – lack of initial implant stability
    - Irreversible tissue damage (drill speed to high, lack of irrigation, burning bone, etc)
    - Premature loading during healing period by denture
      - Micromotion → repair instead of bone regeneration
  - Late failure (after loading)
    - Mechanical overload – bending moment (non-axial loading), cantilever, poor implant distribution, angulation, crown/implant ratio, prosthetic misfit, parafunctional habits, etc
    - Peri-implantitis – mucosal inflammation with corresponding bone loss
      - 12% of implants over 9 years, 58% resolution
- Mechanical/prosthetic problems from overloading
  - Bone loss
  - Implant fixture facture
  - Abutment/occlusal screws fracture
  - Screw loosening
  - Prosthesis fracture, framework fracture, veneers fracture, opposing prosthesis fracture
  - Prosthetic problems – esthetics, speech, lip support, etc
- Miscellaneous problems
  - Soft tissue – gingivitis, mucosal abscess, hyperplasia
  - Fracture of Mn, altered jaw sensation, inhalation of instruments, etc

Implant Survival

  - Early implant loss ~ 2.5% of all implants over 5 years
  - Loss during function = 2-3% supporting fixed prosthesis, >5% in overdentures over 5 years
    - Technical complications greater in overdentures than in fixed prosthesis
  - Implant fracture is rare, <1% over 5 years
    - 0.14% over 2 years
- Implant survival = 96.8%
- Crown survival = 94.5%
  - PFM = 95.4%
  - All Ceramic = 91.2%
- Ceramic/veneer fractures = 4.5%
- Peri-implantitis/soft tissue complications = 9.7% of implants
  - 6.3% implants had bone loss >2.0mm
- Screw/abutment loosening = 12.7%
  - Screw/abutment fracture = 0.35%

Types of Implant Restorations

- Partially edentulous = single, splinted, FPD
- Completely edentulous
    - Mn
        - 5 implant supported Mn fixed complete denture (fixed detachable)
        - 5 implant supported Mn removable complete denture (fixed removeable)
        - 2 or 4 implant retained Mn complete denture
            - Ball/snap/locator attached overdenture
            - Bar overdenture
    - Mx
        - Implant supported Mx fixed complete denture with porcelain
        - Implant supported Mx fixed complete denture (fixed detachable)
        - Implant bar supported Mx removable complete denture
        - Implant retained Mx complete denture (overdenture)

Gingival Fibers

- Biologic width
    - Natural tooth = 2.04mm
    - Implant = 3.0±0.5mm
- Gingival fibers
        - Interdental fibers
        - Dento-gingival fibers
        - Circular fibers
        - Alveolar crest fibers
    - Implants only have circular and alveolar crest fibers – no fibers attach to the implant surface
- Papilla Height
    - <5mm = papilla present 100% of the time
    - 6mm = papilla present 56% of the time
    - >7mm = papilla present <27% of the time
    - Interradicular distance >2.4mm = influence of distance between contact point and crest of bone decreases, papilla height decreases
- Periodontal Fiber Types
    - Thin-scalloped (15% of people)
        - Distinct disparity between gingival margin height on direct facial vs interproximal height
        - Delicate and friable soft tissue curtain, underlying osseous form is scalloped
        - Small amount of attached masticatory mucosa, responds to trauma by recession
        - Subtle diminutive convexities in cervical thirds of facial tissue
        - Teeth triangular in shape, contact areas to adjacent teeth located incisal/occlusally
        - Small contact areas facial/lingually and incisal/gingivally
    - Thick-flat (85% of people)
        - Soft tissue curtain is denser and more fibrotic, underlying osseous form is flatter and thicker
        - Large amount of attached masticatory mucosa, responds to trauma by pocket depth
        - Prominent bulbous convexities in cervical thirds of facial tissues
        - Teeth square in shape, contact areas to adjacent teeth located more towards apical
        - Large contact areas facial/lingually and incisal/gingivally

Esthetics

- Checklist for Mx incisors
  - Smile line
  - Free gingival margin level
  - Gingival zenith – most apical point of gingival tissue
  - Biotype – thick flat or thin scalloped
  - Crest of bone level
  - Buccal/lingual thickness
  - Patient's expectations
- Action Plan
  - Educate patient
  - Site preparation – bone/CT grafting
  - Ideal 3D implant position
  - Emergence profile – axial contour that extends from the base of the gingival sulcus past the free margin and continuous to the height of contour
    - Implant position, B/L angle
    - Implant position, M/D angle
    - Implant position, occlusal/gingivally
    - Proportion of implant size to edentulous space
  - Custom abutment, all ceramic abutment/restoration
  - Immediate implant placement and immediate restoration
    - Flapless
    - Space between buccal plate and implant
    - Bone graft or not
    - Immediate restoration
  - Possibility of revision surgery

Recent Breakthroughs

- Surgical Breakthroughs (less bone loss, better soft tissue maintenance, overall faster and better treatment)
  - 2 stage surgery → 1 stage surgery
  - Sinus lift procedures (osteotome technique)
  - Immediate implant placement
  - Surface treatment – faster osseointegration
  - Minimal invasive surgery (flapless)
  - Precision surgical guide
  - CAS (computer aided surgery), CPS (computer planned surgery), robotic surgery
- Prosthetic breakthroughs
  - Immediate/early loading, immediate restorations
  - Better screw mechanics and minimum abutment fixture connection
    - Internal hex, morose taper, platform switch, conical seal, etc
  - All ceramic abutment and all ceramic restoration
  - CAD/CAM, custom made abutments

Immediate provisional

- Indirect screw or cement retained provisional restorations
  - Take VPS impression of implant
  - Modify Dx cast so implant analogue placed exactly as in patient's mouth
  - Fabricate immediate provisional prosthesis using temporary abutment and temporary crown material from modified Dx cast
  - Temporary is tried and seated in occlusion, proximal contacts, and contours are adjusted
- Direct screw retained provisional (technique sensitive, fast)
  - Temporary abutment tried into patient's mouth and modified
  - Putty matrix premade from Dx cast used to make temporary crown directly in patient's mouth
  - Matrix removed after 1min, screw access is dug out
  - Unscrew temporary abutment/temporary crown complex from patient's mouth
  - Temporary abutment is trimmed, then complex connected to implant via abutment screws
  - Occlusion, proximal contacts, and contours adjusted
- Direct cement retained provisional (most versatile)
  - Temporary abutment tried into patient's mouth and modified
  - Piece of rubber dam applied to protect surgical wound around connected temporary abutment
  - Separating medium applied to temporary abutment
  - Putty matrix premade from Dx cast used to make temporary crown directly in patient's mouth
  - Matrix removed after 1min, temporary crown will come with it because of separating medium
  - Temporary abutment removed, temporary crown placed onto temporary abutment extraorally
  - Separating medium applied to temporary crown
  - Flowable composite applied to temporary abutment – converts into custom modified temporary abutment (requires light curing)
  - Temporary crown removed from custom modified abutment
  - Custom modified abutment screwed back into implant, temporary crown is tried
  - Occlusion, proximal contacts, contours adjusted
  - Crown cemented with weak temporary cement

Lecture 7

2 Implant Retained Mn Complete Denture

- Prosth consult – diagnosis, treatment planning
- Surgical consultation
- Surgical guide fabrication
- 1st stage surgery
- 2nd stage surgery

- Technique 1
  - Locator (or ball) abutment cuff height selection
  - Connection of locator (or ball) abutment to implant, final border molding and impression of implant locator (or ball) abutments
  - Baseplate, wax rim, CR, VDO, and denture tooth selection
  - Process denture with metal housing, deliver to patient
- Technique 2
  - Mn conventional CD fabrication
  - Locator (or ball) abutment cuff height selection, connection to implant
  - Pick up metal housing intraorally with Mn CD

Wound Healing

- Angiogenesis precedes osteogenesis
  - Distance osteogenesis – bone growth towards implant
  - Contact osteogenesis – bone growth from implant towards natural bone
    - Osteoconduction with bone formation
    - Osteoinduction
- Implant microtopography
  - Degree of platelet activation – TGF, PDGF, EGF – mesenchymal cell activation → osteoblasts
  - Fibrin retention – serves as network when osteoblast migrate to implant surface

Implant selection criteria

- Material
  - Titanium alloy is 4x stronger than commercial titanium
- Size and length
  - Implant diameters 3.3mm, 3.7mm, 4.1mm 4.7mm 6.0mm
  - Platform diameters 3.5mm 4.5mm 5.7mm
  - Implant lengths – 10mm, 11.5mm, 13mm, 16mm
- Surface macro and micro design (surface treatment)
  - Macro design
    - Cylinder
    - Threading – shape of threads, size of pitch (distance between the threads)
  - Micro design
    - Unprocessed surface – machined surface
    - Processed surface
      - A – added surface – TPS (titanium plasma sprayed), HA, $CaPO_4$
      - B – subtracted surface – sand blasted, acid etched
        - Anyklosed – grit blasted
        - Astra – TiO blasted, osseospeed (with F^- ions)
        - ITI SLA – sand blasted, large grit acid etched
        - Keystone (lifecore) – RBM (resorbable blast media)
        - 3I – osseotite (Acid etched), nanotite (with CaP)
        - Nobel biocare TiUnite – anodic oxidation
- Abutment/implant connection
    - External hex – 0.7-1.0mm tall hex, for multiple splinted structure
    - Internal hex – >2.0mm tall, for single implant restoration or cement retained FPD
    - Morse taper (cone in cone) – >2.0mm tall, for single implant restoration or cement retained FPD
    - Other
  - Platform switch (shift) – limit crestal resorbtion and seems to preserve peri-implant bone levels
      - Reduction of abutment of 0.45mm on each side
    - Crestal bone loss = 0.2±0.4mm for platform switch implants
    - Crestal bone loss = 1.2±0.3mm for non-platform switch implants
  - Conical Seal
- Price and customer support
- Proven/on-going research records

Ideal abutment/implant junction complex

- Less screw loosening – less prosthetic complications
  - Better screw mechanics, stable connection configuration
- Less crestal bone loss – maintain long term esthetics and function
  - Optimum implant/abutment surface treatment
  - Thin metal collar, microthreads
  - Less stress concentration at neck of implant
  - Platform switch
- Less microleakage – less peri-implantitis
- Flexible to support various options of restorations
	NobelActive
	- High initial stability, even in compromised bone situations
	- Bone condensing properties
	- Redirecting capability for optimal placement
	- Conical connection
	- Built-in platform switch
	- Less stress concentration at neck
	- Dual-function prosthetic connection

Lecture 8

Implant Biomechanics

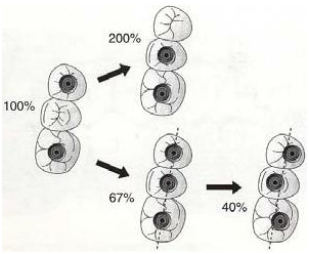
- Successful implants can support forces and deliver them safely to interfacial tissues over the long term
- Challenge is to develop basic science understanding of all aspects contributing to implant performances
    - In vivo loading conditions

▪ Adult molars – 880N ▪ CD – 196N ▪ Implant CD – 412N	▪ Intrusive stiffness • Implant – 4.2N/μ • Molar – 1.0N/μ

        - Bruxism/clenching – 3-10x higher force
        - Lack of posterior support increases force on anteriors
        - Signs of over stress situations – big stature, tori, big chewing muscles, right mandibular angle
    - Load transfer to interfacial tissues
        - Predicting interfacial stress and strain
        - Decide which stress-strain states are conducive to implant success vs failure
        - Stress transfer dependent on
            - Implant in vivo loading
            - Shape of implant
                - Square threads transmit 10x more compressive load than V-threads
            - Mechanical properties of implant interface with hard tissue
                - Fixed – alveolar crest
                - Frictionless contact – apex
            - Nature of interconnection (boundary condition)
            - Quantity and quality of bone contacting implant
    - How biologic tissue reacts to loading
        - Two stages – upon surgery and after initial healing
        - Factors – genetics, diseases, nutrition/hormones, toxic agents
        - About 1mm of bone adjacent to surgical sight undergoes necrosis post-op
        - Wound healing
            - Hematoma, cells, mediators
                - Angiogenesis precedes osteogenesis
            - Implant microtopography
                - Degree platelet activation – mesenchymal cell activation, osteoblast activation
                - Fibrin retention – network for when osteoblasts migrate to implant surface
            - Regeneration vs repair
            - Wound maturation: modeling and remodeling
                - Modeling – shape change
                - Remodeling – old bone replaced by new bone, no shape change
        - Amount of micromotion determines regeneration or repair
        - Implant stability
            - Single stroke – requires single large force to overload implant
            - Fatigue failure
                - 100-300 microstrain = bone loss
                - 1500-3000 microstrain = bone gain
                - >4000 microstrain = bone resorption

Clinical Implant Biomechanics

- Avoid off-axis loading – centric contacts near long axis of implant
- Axial loading of implants – occlusal forces projected vertically, distributed periapically
    - Placing centric contacts as close as possible to the center may be as effective as increasing implant diameter or number of implants
- Off axis loading
    - Natural tooth – lateral occlusal forces dissipated via PDL (shock absorption)
- Cantilever systems – significantly higher forces on crest of bone and on abutment screws
    - A-P spread – line through distal of posterior implants vs line through center of most anterior implant
        - Cantilever should be no more than 1.5x A-P spread
        - 15-20mm spread
        - First molar occlusion
- Crown/root ratio – need minimum 1:1
    - Minimum 6-7mm interocclusal space needed to fit different implant components (shortest components)
    - Best to maximize implant surface area
        - Long term prognosis
        - Amount of arch length space
        - Costs, esthetics
- Allow movement of implant retained CD



Screw Mechanics

- Torque (applied energy) = friction + preload (stored potential energy by elongated screw)
- Preload – screw tension – should be as high as possible within material's elastic limit
    - Increasing surface area of joint screw increases resistance to torque and bending forces
- Settling effect – embedment relaxation – occurs as rough spots are flattened under loading
    - No machined surfaces are completely flat microscopically

Abutment/Implant Connection

    - Implant-abutments with clearance fit have micromotion
    - Implant-abutments with precision conical connections show no micromotion
- Unconnected crowns in posterior region are more susceptible to technical failure of implant-abutment interface
- Pumping effect from micromotion might play important role for crestal bone resorption
    - Assumed that bone is contaminated with liquid contained in the implant
- Things helping conical Seal – microthreading, thin metal collar of metal implant, platform switch, conical seal
- External hex – 0.7-1.0mm tall, for multiple splinted implants
- Internal hex or morse taper – >2.0mm tall, single implant restorations or cement retained FPD

Lecture 9

Chemical surface treatment – faster and stronger bone formation

- Osseospeed (F^-)
- Nanotite (Ca-P)
- DCD (discrete crystalline deposition)
- HA coated implant

Osteoinduction

- BMP, TGF-β, rhPDGF, genes
- Challenges – how to attach mediators to implant surface, how to control release of mediators?

Hardware and design

- Alpha bio implant, nobleactive implant – drilling protocol is 0.7-1.5mm less, than implant diameter
- Bicon implant – taper and larger crestal radius at shoulder reduce stress better than conventional implants

Custom Implants

- Imaging – bone quality/quantity
- CAD/CAM – shape/thread design, surface treatment
- Custom implant for patient and site

- Customized implant treatment planning
    - In vivo loading condition
    - Healing capacity (loading condition)
    - Local bone quality
    - Implant features
  - Site-specific treatment plan
    - Immediate loading, early loading, conventional loading, or delayed loading
    - Types of restoration, # of implants, location, length, and implant diameter

Lecture 10

Restoration Options

- How much sound tooth structure remaining, can it retain core?
  - Caries/faulty restoration removal
  - Root canal treatment, if needed
  - Crown prep, if needed
- How much stress will be applied to tooth, can it resist crown fracture at the neck of the tooth?
  - Single crown vs RPD/FPD abutment
  - Eccentric guidance
  - Occlusal force (anterior vs posterior), parafunctional habits
- If yes to both questions, core buildup indicated
- If no to either/both questions, place post before core buildup

- Consider longevity of treatment, cost of treatment, patient preference, other options (FPD, RPD, implant)
  - Endo treated teeth have similar fail rate to implants
  - Implants take longer to time to function, higher rate of complications

Endo treated teeth

- Require crown due to access opening – reduce tooth stiffness by 5%
  - Molars without crowns lasted 36% over 5 years
  - Crowns should be placed on posteriors and anteriors without sound structure
- Ferrule of 2.0mm high, 1.0mm thick needed
- Posts are to retain core, they do NOT reinforce endo treated teeth
  - May help prevent coronal fracture
  - Should use adhesive resin cement
  - Threaded posts cause root fracture
- Primary problems
  - Core without post – crown dislodgment and root fracture
    - Extract tooth if it doesn't have adequate ferrule, or use post if not enough walls for retention
  - Post – debonding
    - Use resin cements for cast D&C and for prefabricated posts

Treatment Planning

- Complete oral evaluation
- Data collection
  - Perio health
  - Quality of NSRCT
  - Occlusal scheme
  - Parafunction
  - Intended tooth function – single restoration, abutment for RPD/FPD/overdenture
  - Crown lengthening – root length, crown/root ratio, furcation location, taper of root
  - Vertical space for crown

Treatment Sequence for Cast D&C

- Pre-Op radiograph
- Crown preparation
- Canal preparation
    - Mid-op radiograph
- Finalization of canal prep
- Direct cast D&C pattern fabrication
- Fabrication of provisional crown with cast post and cementation
- Casting of direct D&C pattern
- Cementation of cast D&C
- Refining crown margins
- Final impression for crown fabrication
- Provisional crown fabrication
- Crown fabrication, cementation

Canal Preparation

- Length of dowel = crown length
- Length of dowel = 2/3 root length
- Length of dowel under bone = 1/2 root length in bone
- Dowel diameter not >1/3 root diameter
    - Minimum 1.0mm dentin around all sides
- Always leave 4-5mm gutta percha for hermetic seal
    - If not possible, likely from
        - Excessive crown/root ratio (short root)
        - Excessive bone loss
        - Losing of apical seal

Fiber Posts

- Advantages
    - Matrix is epoxy resin – highly polymerized
        - Fibers are made of glass or quartz
        - Do not need to silanate fiber posts
    - Greater bond strength to dentin compared to zirconia posts
    - Less likely to cause root fracture compared to metal or zirconia posts
        - Forces on tooth apparently absorbed by fiber post, less transferred to interface to root structure
            - Metal posts induce greatest stress concentration at post/dentin interface
        - Stiffness similar to dentin – lower stress in dentin compared to metal posts
    - Lower modulus of elasticity (more flexible), greatest resistance to mechanical fatigue
    - Single session post placement
    - Good esthetics, easily trimmed, biocompatible, relatively less expensive than cast metal posts
    - Easier to repair

- Disadvantages
  - Expensive
  - Variable radiopacity among fiber posts
  - May flex under loading (modulus of elasticity similar to dentin)
  - Ferrule of 2.0mm required to stabilize core retained by fiber post
  - Cylindrical shape – do not adapt well to root canals
- Placing Fiber Posts
  - Significantly improve survival rate of RCT restored premolars
  - Preservation of at least 1 coronal wall significant reduces failure risk
  - Use fiber posts if 1-2 walls remain – significantly influences facture resistance
    - Use fiber post with composite buildup if marginal ridges are lost/destroyed
    - Use cast D&C if 0-1 walls remain
  - Fiber posts are used for retention, NOT resistance
    - Incomplete crown ferrule associated with greater variation in loading capacity and fracture
      - Study showed 2.0mm ferrule gives better clinical survival after 3 years
  - Preservation of root dentin is desired, more residual tooth structure = better prognosis
  - Serrated posts do NOT increase retention – cement is source of retention
    - Composition of sealer (eugenol) doesn't affect retention of posts cemented with adhesive/resin
  - Fiber posts do not allow significant light through to cure deep cements
  - Cements are usually self-adhesive cements now
    - Used to be adhesive system with a resin cement
- Removing Fiber Posts
  - Peeso reamers are as effective as sophisticated removal kits provided by manufacturers
- Buildup Materials
  - Glass ionomer cement not reliable as core buildup material
    - More defects than amalgam
    - Inadequate fatigue resistance
    - Amalgam combined with cement is not strong enough either
  - Heavily filled composite resins without esthetic properties
    - Average particle size usually greater than that used for esthetic restorations
    - Meet minimum requirements for buildup material
      - Compressive strength, elastic modulus, diametral tensile strength, flexure strength
  - Available as self cure, light cure, dual cure
    - Self cure hardness – very low @ 10min
    - Dual cure hardness – when light cured, hardness @ 15-30min similar to 24h later
      - Can proceed with crown prep shortly after inserting buildup material
  - Clinical reliability influenced by:
    - Cutting forces – crown prep after polymerization of core buildup material
    - Withdrawal forces – impression material
    - Removal forces – provisional crown
    - Masticatory forces – loading
- Incremental Curing (maximum 2.0mm increments)
  - Decrease dimension change (limit volumetric shrinkage – for paracore = 5.7%)
  - Allow light cure to reach lowest layers of buildup material
    - Do not rely on self-cure ability

Lecture 11

Decision Making – Extractions

- At initial treatment planning
  - NOT after NSRCT is completed
- If tooth is borderline, have an EXTRA (explanatory) appointment to remove caries and do crown preparation to make decision
  - Will also help for making decision on whether endo is needed, elective endo, and buildup with pins
- Take radiographs, clinical exam, and consider entire oral cavity health

Decision Making – Crown Restoration

- At treatment planning appointment, estimate how much tooth structure will remain
- Be ready for emergency endo during 2nd appointment – removal of caries/old restorations
- After endo treatment – imagine how much ferrule will be left after crown preparation
- Still need to consider overall treatment for the entire oral cavity

Lecture 12

Cast Dowel and Core

Length	Width
- As long as possible, maintain 4-5mm apical seal ○ Retention = proportional to dowel length ○ Longer = more evenly distribute force over root length - Should = crown length - Should = 2/3 root length - Should be at least 1/2 submerged in bone	- No greater than 1/3 diameter of root - Must have at least 1.0mm dentin thickness on all sides - Should be parallel sided - Should be rough surfaced but fit/seat passively - Should have a vent – easy escape for excess cement

Common Failures

- Loosening of post
- Tooth fracture
    - Commonly subalveolar/vertical root fracture
        - Prefabricated/fiber post and core generally fracture AT gum line
    - Strength of entire structure limited to strength of weakest component

Cast Post&Core and Crown Design

- Finish line (bevel) for PFM margin
- Contrabevel at top margin of ferrule (no sharp corners on external side of buildup)
- Keyway ensures no rotation of the post internally
- Slots/channels do not provide sufficient retention for core buildup

Radiographs

- Pre-operative (after NSRCT)
- During/after preparation of post space (determine further need for canal prep, if needed)
- After cast dowel/core prepared onto tooth, before cementation (ensure complete seating of post)

Casting and Finishing

- Minimize expansion during casting
    - Add extra 1.0mL water to investing material
    - Do not use ring liner
- Cast in type III gold
- Examine casting under microscope for bubbles
- Sandblast
- Place vent on largest flat surface (use ½ round bur)

- Do not force post into canal – using indicator (fit checker) to find where binding site is, modify appropriately

- Cements – ZPC, GI cement, RMGIC (Rely X luting), resin cement, para post cement, unicem (selfetching dualcure)

Indirect Technique

- Use Cast D&C when:
    - Only 1 wall left, only ferrule left (no walls), compromised ferrule tooth structure exists
    - Multiple teeth need cast D&C – full mouth reconstruction (use indirect technique because of clinic time)
    - Divergent multi-root posts needed