A surgical and restorative blueprint for ideal implant esthetics: a vision for success and change

Introduction

Esthetics: the tissue-restorative interplay
- Changing tooth contour, shade.
- Position of the restoration margin.
- Surgically altering the periodontal framework where necessary (resective or regenerative procedures).

Illustrative cases with optimal pretreatment tissue levels vs. deficient or excessive tissue levels. Emphasis of this discussion will be on the interplay between soft tissue framework and restorative treatment for optimal esthetics, and the importance of the restoration margin position and its impact on tissue health.

Lecture format: 10 Steps to Esthetic Implant Restorations: a blueprint for success and change
- Hard tissues
- Surgical strategies
- Implant position
- Implant and abutment design
- Gingival biotype
- Provisionalization
- Accurate impressions
- Zirconia Abutments
- Ceramics
- Inter-implant papilla

Hard tissue defects:
Corrective procedures - setting realistic outcome expectations


Ridge height deficiencies:
Rarely corrected ideally. Requires staged treatment with delayed implant placement following bone grafting (orthodontic site development, guided bone regeneration procedures or onlay grafts, distraction osteogenesis). Vertical bone repair is still unpredictable and rarely recreates optimal bone/soft tissue levels.
- Computer guided surgery: strengths and limitations will be illustrated, discussed and referenced. Deviations between planned and executed implant placement is discussed, with reference to the challenges of restoration at the time of implant placement.
• Deviations: Average angular deviations: 4.9° to 7.9°, mean linear deviations at collar of 1.22 to 1.4mm +/-, at apex 1.51 to 1.6mm +/-.
• Errors: image acquisition and data processing, surgical template production errors, template positioning errors, template movement during drilling, mechanical errors (bur to cylinder fit), freehand drilling deviation (limited opening, guide removal), human error.

Reference:

• The important role of pink ceramics or acrylics will be discussed.

• **Block grafts** are often used to manage vertical ridge deficiencies and severe horizontal defects. New techniques, materials and limitations with reference to block allografts will be illustrated.

• Site management considerations: regional acceleratory phenomenon (perforations to increase vascularity), stabilized cortico-cancellous block allograft, surrounding particulate cortical allograft or xenograft, cross-linked resorbable collagen membrane.

References:

References relating to 3D implant positioning for optimal bone stability:
• **Bucco-lingual considerations:** Spray RJ, Black CG, Morris HR, Ochi S. The influence of bone thickness on facial marginal bone response; Stage 1 placement through stage 2 uncovering. Ann Periodontol 2000;5:119-128.
• **Apico-coronal considerations and contact point:** Tarnow D, Elian N, Fletcher P et al. Vertical distance from the crest of bone to the height of the interproximal papilla between adjacent implants. J Periodontol 2003;74(12): 1785-1788.

**Ridge width defects: avoiding this problem through socket preservation:**

Facial/lingual/palatal bone level deficiencies: Correction of facial or lingual/palatal defects in conjunction with implant placement is often possible, as long as the ridge permits adequate primary implant stability and implant placement in a prosthetically directed position. Autogenous bone, allografts, xenografts, etc. Often coupled with membranes to confine the graft material. Structurally stable or non-resorbable products may be preferential for long-term tissue esthetics (example, xenograft/bovine bone- Bio-Oss from Osteohealth).

Lecture will review our current hard tissue grafting strategies including autogenous or allogenic bone grafts, bone substitutes (bovine bone or allogenic particulated graft materials, coupled with membranes).

If there is bone loss that prevents immediate implant placement in a prosthetically driven position with adequate primary stability, it is highly recommended to consider ridge preservation at the time of tooth extraction in the esthetic zone, in order to prevent unfavourable post-extraction ridge remodeling.
Horizontal ridge resorption: 5-7mm; vertical ridge resorption: 1mm (single extractions), 2-4.5mm (multiple adjacent extractions).

REFERENCES:


Ridge preservation considerations:

- Atraumatic extraction is the first key step: will be discussed later on.
- Effect of flap vs. no-flap extraction techniques: 14% greater bone volume change with flap in Fickl study, no difference in Araujo study.

REFERENCES:

- Bone graft products in the extraction site (wide material selection options): materials illustrated include Zimmer’s Puros (particulated cortical or cancellous bone allografts), BioHorizon’s Neoss (particulated cancellous bone) or Dentsply Tulsa MTF allograft (cortical or cancellous mineralized granules). Similar results, cost differences.

REFERENCE:

- Resorbable membranes (collagen based membranes like Bio-Gide from Osteohealth, Biomend Extend or Socket Repair Membrane from Zimmer, Cytoplast from Dentsply/others) or non-resorbable membrane for graft confinement (polytetrafluorethylene products: relatively high infection risk if exposed, or titanium meshes/cribs). Synthetic membranes are also widely available. Membranes are essential in the repair/regeneration of 1 and 2 wall defects around implants and in bone grafts prior to implant placement. Resorbable membranes are simpler to use for the less experienced clinician with less post-surgical complications. Resorption times vary.
- Socket seal free gingival graft plugs (as described by Cobi Landsberg) or connective tissue graft to seal the extraction socket and to improve the biotype. Grafting to seal a socket is preferential to flap advancement because it does not change the mucogingival junction position and because it simultaneously enhances soft tissue quality. The issue of socket closure with gingival grafts is discussed. It is not always necessary to incorporate a graft; generally incorporated only when the gingival biotype is thin.
  - Use of a rapidly resorbing collagen sponge like Collaplug (Zimmer) is illustrated. Similar socket seal technique used in Wang histologic study.

**Vertical ridge enhancement with orthodontic site development:**
• If there is bone loss or unfavourable soft tissue levels around the tooth to be extracted, consider site development with orthodontic extrusion.
• Requires an intact PDL in the apical 1/3rd of the root being extruded. (Relatively simple, with appropriate orthodontic treatment and appropriate vector of root extrusion).
• Light forces (.3 to .5N) results in tension to the PDL, elongating periodontal fiber bundles, inducing osteoblasts to deposit bone where there is a periodontal attachment.
• Extrusion to produce a 25-30% facial and interproximal hard/soft tissue excess relative to contralateral tooth: generally end up with soft tissue levels that are ideal after implant restoration. Some clinicians prefer to extrude to the point of extraction for more bone and soft tissue development, but this necessitates tissue removal in conjunction with implant placement and visualizing the ideal hard and soft tissue positions.

REFERENCES:
• Esthetic assessment or scoring systems: Pink Esthetic Score discussed (Furhauser et al. Clinical Oral Implants Research, 2005). This scoring system will be discussed. The value of using some kind of scoring system will be emphasized.

Surgical Strategies in the esthetic zone:

Atraumatic extraction: minimizing bone loss with a variety of extraction tools. Benex extractor and Physics forceps will be presented.
• Periotomes.
• Vertical root extraction system like the BENEX extractor from Meisenger Corporation (Germany), BioHorizons (Canada), Karl Schumacher (US).
• Golden-Misch Physics forceps.

Antibiotic protocols:
Systemic antibiotic coverage recommendations:
• More implant failures in treatment group not receiving antibiotics.
• Some evidence that 2g amoxicillin given pre-operatively significantly reduces failures.
• Impact of post-operative antibiotics remains unclear.
Some reports prior to systematic review suggest that there is no benefit from post-surgical antibiotics based on a review of complications of surgery (Bin hamed 2005 meta-analysis of 2 randomized clinical trials).

REFERENCES:

Immediate implant placement at the time of extraction:
Determine whether immediate implant placement can be considered. Case selection criteria are still ill-defined in the literature and are subjective. If there is bone loss that can be corrected with bone grafting/guided bone regeneration, and there is adequate residual bone for primary implant stability, consider immediate implant placement. (Moderate degree of difficulty: flap management skills need to be more developed). Infection must be eliminated with extraction and site preparation.

REFERENCE:
• Benefits of cross-sectional imaging will be discussed.
• Implant must be placed in a prosthetically driven position. This generally means that it is important to not follow the prior root angulation/socket or to place the implant where the bone is.
• Implant selection: in immediate implant placement, tapered implant designs have the advantage of enhanced primary stability compared to cylindrical implants. Rough threaded implant surfaces increase surface area which is important for immediate restoration/loading. Lang NP, Tonetti MS et al. Clin Oral Implants Research 2007.
• Implant insertion: Adequate insertion torque (generally accept 45Ncm torque).
• Appropriate implant positioning in 3-dimensions (reviewed below). Critical to success.
• Residual hard and soft tissue defects: mild to moderate. Can be corrected at the time of implant placement with guided bone regeneration and connective tissue graft where necessary. This was discussed in the bone grafting segment. Recent article that provides some guidelines as to case selection:

REFERENCE:
• Submerged healing is not necessary, if the site has no or minimal grafting requirements. Submerged healing is considered if there is moderate to severe bone loss.
• Antibiotic protocols: empiric. Some evidence that 2grams Amoxicillin preoperatively significantly reduces failures. Post-operative benefit remains unclear.

REFERENCE:

**Immediate implant loading/restoration:** when is it appropriate?

  - **REFERENCE:** position statement from the ICOI!
  - Adequate primary stability (35-45Ncm), minimally invasive surgical procedure, no parafunction or controlled with guard, occlusion controlled (typically non-functional loading in the case of a single implant). Some studies use functional loading with no excursive contacts.

**Implant Position- key considerations:**

**Implant selection** is based on bone quality, ridge anatomy, space available and operator preference.

- **REFERENCES:** multiple including
  - Saadoun, LeGall, Touati. Pract Periodontics Aesthet Dent 1999;11:1063-1072. and
  - **Bucco-lingual:** restoratively driven position with angulation slightly lingual to the incisal edge or in the cingulum position if screw-retention is desired. In the case of immediate implant placement, do not follow the typically buccally dominant root position since this places the implant too buccal. Do not necessarily chose the largest implant to fill the extraction socket. Maintaining a residual horizontal defect presents the opportunity for buccal bone augmentation for enhanced ridge stability and decreased recession risk. References on residual horizontal defect issue:
REFERENCES:

- Chen ST, Darby IB, Reynolds EC. A prospective clinical study of non-submerged immediate implants: clinical outcomes and esthetic results. Clin Oral Impl Res 18:2007;552-562. This study supports the important role of anorganic bovine bone (Bio-Oss) in the residual defect to reduce facial ridge resorption and the impact of buccally positioned implants on post-restoration recession.

- **Apico-coronal:** Position the collar of the implant 2-3mm apical to the ideal buccal free gingival margin position. Adequate depth is particularly important for platform-switched implants which have an under contoured subgingival profile.
  - Implant site preparation and placement. Adhere to surgical protocol which differs for different implants, respect recommended drill speeds and irrigation/cooling protocol.
  - Intra-operative radiographs with direction indicators are valuable to confirm M-D and depth positions during preparation, especially for the less experienced clinician.
  - Insert implants with approximately 35Ncm torque. More torque increases the risk of damage to the implant connection and instruments and may increase risk of compression necrosis of bone. If the implant inserts with less than 35Ncm torque, primary stability is poor. Consider submerging the implant for healing in a 2-stage protocol, re-prepare/reinsert, or remove implant.

- **Mesio-distal:**
  - Maintain minimum 1.5 distance from adjacent roots. If space is lacking, consider treatment alternatives (bridge, maryland bridge, orthodontic treatment, small diameter implants (?)).
  
  **REFERENCES:** maryland bridge statistics: Prosthetic success of resin bonded bridges
  - Salinas TJ, Eckert SE. IJOMI 2007;22 (suppl):71-95. Prosthetic success: 5 years (84%), 10 years (81.3%), 15 years (67.3%).
  - Maintain minimum of 3mm between adjacent implants according to most literature, but we feel that we are more successful at maintaining papilla form by keeping adjacent implants 4 to 4.5mm apart.

  **REFERENCES:**

- **Maryland bridge survival/success references:**
  - o Salinas TJ, Eckert SE. IJOMI 2007;22(suppl): 71-95. Prosthetic success: 5 years- 84%, 10 years- 81.3%, 15 years- 67.3%.
  - o Pjetursson BE, Tan WC, Tan K et al. COIR 19;2008: 131-141. Survival after 5 years 87.7%. Debonding most frequent complication.

**Implant and Abutment Design:**

**Abutment design** advances to thicken the zone of connective tissue and reduce crestal remodeling.

**REFERENCES:**
Linkevicius T, Apse P, Grybauskas S et al. The influence of soft tissue thickness on crestal bone changes around implants: a 1-year prospective controlled clinical trial. Int J Oral Maxillofac Implants 2009:24; 712-719. Tissue thickness <2.5mm, resulted in crestal bone loss of 1.45mm vs. thicker tissues 0.26mm. Occurred despite supracrestal position of implant-abutment interface.

Implant design advances to minimize crestal ridge remodeling
- Elimination of smooth collar and new surfaces and crestal threads (reduce crestal shear forces).
  - Microthreads (Hanson S. Clin Oral Implants Res 1999), rough surface implants (Zechnner W et al. IJOMI 2004), combination of both (Shin YK et al. IJOMI 2006).
- Thicken the connective tissue barrier: Abutment design changes to enhance soft tissue stability which acts to protect underlying bone (concave form or platform shifting, or ‘O’ ring designs to thicken the poorly vascularized CT layer). This is inherently done in platform switched abutments and can be CAD-designed for most implant abutments.
- Eliminate the microgap with one-piece implants, move the microgap coronally with scalloped/physiologic implants or platform switching which moves the implant-abutment microgap medially and away from bone. These 3 options reduce the impact of the dirty junction on crestal bone and reduce or eliminate the impact of micromovement on crestal bone. Platform switching is a commonly used design today and is increasingly studied/referenced.

REFERENCES: relating to implant design evolution
- Gallucci, Belser, Bernard, Magne. IJPRD 2004;24:19-29), move the microgap medially (platform switching).

Platform switching cases to illustrate the impact on bone.
- Crestal bone response to immediate or delayed placement into an extraction site with immediate provisionalization is similar regarding hard tissue changes. The immediate group with provisionalization preserved 1mm more facial gingival margin tissue levels. Statement: establishing positive contours permucosally improves the cleansibility of the wound margin, therefore may reduce bone resorption.
- Fixed provisional restorations resulted in better inter-implant tissue levels than in cases were removable restorations were transitionally used.
- 3D Implant positioning in conjunction with platform switching.
  - Papilla height between implants: average 3.4mm, standard deviation 1-7mm. Tarnow D, Elian N, Fletcher P et al. 2003.
  - Contact point to bone crest: 3mm- papilla present 100% of the time. Gastaldo JF et al. 2004; ideally 3-4mm and always less than 6mm. Degidi M, Novaes Jr AB, Nardi D, Piattelli A. 208.
  - Spacing recommendations between implants: 3-4mm. Gastaldo JF et al 2004; >3mm Grunder U, Gracis S, Capelli M. 2005; >2mm and <4mm Degidi M et al. 2008.

Connective tissue graft procedure:
- Gingival level in the site being treated and comparison with level on the contralateral tooth.
  - Excessive preoperative gingival level (favourable site). Simple to treat since adjunctive soft tissue augmentation is not required. Multiple options for treatment, including immediate implant placement and restoration.
• **Ideal preoperative facial tissue level** (demanding site- no room for tissue change). Need to consider soft tissue grafting (CTG) and provisional restoration design to maintain and possibly improve the tissue level and quality and to prevent the typically expected 1mm of post-restoration recession. Multiple treatment options possible, including immediate implant placement and restoration.

• **Preoperative facial tissue deficiency** (unfavourable site).
  - Ideally, consider site preparation with orthodontic extrusion if possible.
  - Often best handled by staging treatment. Extraction and ridge preservation, followed by implant placement. In unskilled hands, do not consider immediate implant placement. Referral to specialist recommended as multiple adjunctive procedures often required to achieve optimal outcome.

• **Pre-operative papilla (interproximal) deficiencies**- most challenging situation. Rarely possible to improve papilla height around implant. Referral to specialist highly recommended.
  * Adjacent implant placement can have a negative impact on papilla form, especially in thin and highly scalloped gingival types. This will be reviewed in final lecture subtopic.

• **Gingival biotype**. Probe shines through sulcus = thin.
  - **Thick tissue biotype** (favourable). Often a flat gingival profile, often square-shaped teeth (favourable). Adjunctive tissue grafting not usually required, unless there is a quantity deficiency/recession.
  - **Thin tissue biotype** (unfavourable). Consider connective tissue graft procedure in conjunction with implant placement or during provisionalization phase of treatment. Slight circumferential under-contouring of the provisional restoration/abutment form coupled with a graft will help thicken the CT volume.

• **CT graft surgical instruments**
  - Microsurgical blade for recipient site preparation: (Ophthalmic knife- imedpharma Sharpoint 1.25mm minicrescent knife angled REF 74-6910). Graft stabilization with cyanoacrylate adhesive (Glustitch PeriAcryl or others). Suturing palate and at times the graft with 6-0 PGA or 7-0 Vicryl sutures (multiple manufacturers). PGA is a slowly dissolving suture with good stability and predictable knot.
  - Advantages of microsurgical recipient flap management vs. macrosurgical preparations.

**REFERENCES:**
- Burkhardt R, and Lang NP. Coverage of localized gingival recessions: comparison of micro- and macrosurgical techniques. J. Clin. Perio 2005;32:287-293. **Findings:** vascularization was best at all times studied with microsurgical approach. Root coverage was about 8% higher.
- Reiser GM et al. The subepithelial connective tissue graft palatal donor site: anatomic considerations for surgeons. IJPRD 1996;16:131-137. **Findings:** looked at effect of palatal vault in terms of height/dimension of donor tissue available relative to greater palatine artery. High, average, shallow palates.
- Studer SP et al. The thickness of masticatory mucosa in the human hard palate and tuberosity as potential donor sites for ridge augmentation procedures. J Periodontol. 1997;68:145-151. **Findings:** 1st molar areas is an anatomic barrier (bony protuberance).
- Monnet-Corti et al. Connective tissue graft for gingival recession treatment: assessment of the maximum graft dimensions at the palatal vault as a donor site. J Periodontol. 2006;77: 899-902. **Findings:** minimum 5mm graft height can be harvested in even a shallow palate.
- Han JS, John V et al. Changes in gingival dimensions following connective tissue grafts for root coverage: comparison of two procedures. J Periodontol 2009;79:1346-1254. **Findings:** compared exposed ct graft vs. covered with flap. NSD at 12 weeks re root coverage %. complete root coverage, change in keratinized tissue width.
- Zigdon H, Machtie EE. The dimensions of keratinized mucosa around implants affect clinical and immunological parameters. COIR 2008;19(4): 387-392. **Findings:** thin tissues receded 2X more than thick biotype cases. Thin tissues had higher levels of inflammatory mediators.
Provisionalization:

- Provisionalization is critical to developing or guiding optimal soft tissue esthetics, whether it is started prior to implant placement (ridge preservation), in immediate implant placement and restoration or in delayed implant placement or loading protocols. Multiple provisionalization techniques are reviewed (chairside screw-retained or cemented on prefabricated zirconia abutments, or fabricated by lab). Typical soft tissue maturation time: 3-6 months prior to final impression.
- Provisionalization in pontic sites to guide the soft tissue healing. This can be done with fixed or removable partial dentures. Proper pontic design is essential to guiding soft tissue form. Technique to convert flat to scalloped ridge will be reviewed. Role of the biotype on tissue stability must be considered. Pontic contours discussed (elliptical but support facial tissue for at least 1.5mm), not overly compressive. Hygiene: avoid flossing until epithelization complete (about 3 weeks).

REFERENCES:


Impression technique:

- The most predictable technique involves customizing the impression coping with composite to more accurately register the subgingival prosthetic envelope anatomy. However, even tissues that have been well-developed with a provisional restoration can be prone to collapsing when the restoration is removed, especially when the gingival biotype is thin and/or there is inflammation.
- Customizing an abutment based on registration/indexing of the provisional crown form accurately transfers information about the desired crown and abutment contours to the ceramist.
- Intraoral technique- customizing an impression coping: if the soft tissue form that has been developed by the provisional is very stable upon removal of the temporary crown/abutment, this technique is simple to use. Remove provisional restoration, seat a narrow diameter impression coping, apply flowable composite to the subgingival envelope that was created by the provisional, light cure. Customized impression coping has been fabricated intraorally and impression can be taken immediately.
- Extraoral technique- customizing an impression coping: Intra-orally, mark the gingival level with pencil on the screw-retained implant-level provisional restoration. Remove (unscrew) the provisional restoration. Attach the provisional restoration/fused temporary abutment to an implant replica. Wrap bite registration paste around the ‘root’ area of the provisional restoration up to the line that was drawn in pencil. Place the implant analogue/provisional restoration/bite registration index complex into fast set stone. After setting, unscrew the
provisional restoration- this will leave an accurate representation of the subgingival prosthetic envelope that was developed by the temporary crown in the stone. Place/screw-in an impression coping into the implant replica in the stone. “Customize” the impression coping with flowable composite and light cure. Remove/unscrew the customized impression coping, add an implant analogue to it and seat intraorally, to accurately record the implant position and the idealized tissue form in an impression (PVS or other).

**Abutment selection:**

Zirconia abutment advantages over titanium abutments in the esthetic zone:

1. **Coronal movement of the cement line** facilitating the cementation process and avoid cement entrapment

   **REFERENCE:**

2. **Enhanced tissue coloration:** avoiding the graying effect of titanium abutments.

   **REFERENCE:**
   - Jung RE, Sailer I et al. In vitro color changes of soft tissues caused by restorative materials. Int J Periodontics Restorative Dent 2007;27:251-257. Titanium induced most mucosa color change compared to zirconia, ceramic-veneered zircon and ceramic-veneered titanium. Mucosa thickness significantly influences the color change (1.5, 200 mm thickness), 3mm thick tissue- no material induced color change.

3. **High flexural strength/resistance to fracture** for restoration of anterior implants (Zirconia approximately 1000MPa flexural strength, Alumina approximately 600-700 MPa).
   - Peak occlusal forces in the incisor area: 90-370N (Paphangkorakit et al 1979), 150-235N (Haraldson et al. 1979).

4. **Excellent bio-compatibility and low plaque-retention.**

   **REFERENCES:**
compared to titanium. Titanium surfaces appeared to be coated uniformly with biofilm structures, whereas zirconium surfaces were colonized by clusters of bacteria. Considered to be of decisive importance for peri-implant soft tissue health.


Ceramics:
The final esthetic step

- **High strength**: fracture strength vs. maximum biting forces is favorable (biting force is lowest in incisor region and highest in the molar region, influenced by age and complete/shortened arch).
- Effect of cement on fracture strength is discussed (zinc phosphate: 1787.6N, resin modified glass ionomer 1979.8N, resin cement 2782.0N).
- **Cement types**:
  - Type I (total etch)- Calibra, RelyX Veneer, Variolink II, Nexus 2n, NX3
    - Advantages include: excellent esthetics, high strength, no solubility, light or dual cure, adheres to tooth with adhesive.
    - Disadvantages include: some post-op sensitivity, high cost, technique sensitive.
  - Type II (self-etch primer)- MultiLink Automix, Panavia F 2.0.
    - Advantages include: good esthetics, high strength, no solubility, light or dual cure, adheres to tooth with separate primer, low post-op sensitivity.
    - Disadvantages include: infrequent post-op sensitivity, high cost, some technique sensitivity.
  - Type III (self-adhesive)- Maxcem, RelyX Unicem, RelyX Unicem Clicker, G-Cem.
    - Advantages include: good esthetics, high strength, no solubility, light or dual cure, easy to use/clean-up, no post-op sensitivity.
    - Disadvantages include: high cost, adhesion lower than types 1 & 11, needs more long-term research.
- **Cementation protocol**: decontamination with phosphoric acid, quick sand-blast 50um Al203 60-100 PSI, Clearfil SE Bond Primer and Porcelain bond activator (effect of Silane- increases the wetability and cement flow), Panavia F 2.0 cement or other cement.

REFERENCE:

- How to adhesively bone to zirconia: use of adhesive monomer containing primer or resin cement:
strengths to high-strength ceramics. Materials with adhesive monomers that can chemically bond to metal oxides are required.

- **Adhesive bonding technique** for zirconia/teeth will be reviewed: clean restoration with phosphoric acid, clean intaglio surface by sandblast internal surface (50um Al₂O₃ 1 bar at 10mm distance, ultrasonic 2-3 min with isopropanol solution and then air dried, phosphate monomer ceramic primer application or MDP-containing resin cement, condition tooth, apply cement.

- **High clinical success rates**: comparison of all-ceramic restoration vs. metal-ceramic restorations 5 year survival rates.
  - Crowns- implants:
    - % overall implant survival: 96.8%
    - % overall implant crown survival: 94.5%
      - PFM crowns: 95.4%
      - All-ceramic crowns: 91.2%
    - **Complications**: peri-implantitis & soft-tissue complications 9.7%, bone loss > 2mm 6.3%, implant fractures 0.14%, screw or abutment loosening 12.7% (outlier study), screw or abutment fracture 0.35%, ceramic or veneer fracture 4.5%.
  - Fixed partial dentures:
    - % overall survival: ceramics 88.6% vs. metal-based 94.4%.
    - Reason for failure in the ceramic FPDs were technical and biological and not related to framework failure.
    - Screw loosening: a rare event provided that there are anti-rotational features and that proper torque is used.
    - Esthetic outcomes of implant-supported restorations:
      - 7 of 26 studies evaluated esthetic outcomes: 8.7% unacceptable or semi-optimal, no standardized esthetic criteria.
    - Ceramic fractures appear to be the most common clinical failure for all-ceramic crowns. Etiologic issues in cohesive failures:
      - o occlusal contact position
      - o scanning or core support
      - o rate of cooling after porcelain application
      - o zirconia as a heat insulator
      - o porcelain adjustments

**REFERENCES:**

- **Relative translucency and masking ability**
- **Marginal fit**
Marginal discrepancy before and after cementation occurs regardless of combinations of finish lines and luting agents tested. Procera (25/44um), Empress 2 (68/110um), InCeram alumina copings (57/117um).

**REFERENCE:**
- Quintas AF et al. JPD 2004 vol 92 #3.
  - Ketac cem: try-in accuracy 32.7 +/- 6.8um vs. post-cementation 44.6 +/- 6.7um; Panavia 33.0 +/- 6.7um at try-in vs. 46.4 +/- 7.7um post-cementation.
- Good ML et al Quantification of all-ceramic crown margin surface profile from try-in to 1-week post-cementation. J Dent. 2009 Jan; 37(1): 65-75. Findings: From crown try in to 1 week later, SD for dual cure resin > light cured resin > resin modified glass ionomer.
- Discussion on change of film thickness of different luting cements over a 1, 2 and 3mm post-mix time. All tested luting agents showed an increase in film thickness, but significant for Fijicem and RelyXARC from 2 to 3 minutes, RelyX Luting Plus from 1 to 2 and 2 to 3minuts.

**Ease of preparation, ease of fabrication (CAD CAM)**

**REFERENCES:**
- Reich S et al. The effect of finish line preparation and layer thickness on the failure load and fractography of zirconia copings. J Prosthet Dent 2008;99:369-376. Findings: Knife edge preparation can be an alternative when minimally invasive preparations are required. 38% increase in fracture load relative to a chamfer prep.

**Coupled porcelain system for strength and esthetics**

**Range of use in the dentition**

**REFERENCES:**

**Adjacent implant placement challenges:**

The papilla anatomy that can be generated between adjacent implants is often less well developed that when a tooth bounds an implant. This portion of the lecture will review the challenge of papilla preservation between implants and will review various surgical and restorative principles and techniques that can increase the likelihood of conserving tissue architecture from the time of adjacent tooth extraction through the implant surgical and restorative phase. **Average papilla height between adjacent implants: 3.4mm (range 1-7mm).**


Today, it is increasingly recognized that adjacent and immediate implant placement presents esthetic risks for tissue stability and alternative treatment approaches are often considered (early, delayed or sequential implant placement).

**REFERENCES:**

