Now that we have examined the cast metal frameworks which are part of RPDs, let’s consider the acrylic portions.
RPDs typically involve acrylic resin teeth bonded to acrylic saddles made from denture base material. There are a variety of problems that may arise as one can see by reference to the cross-section through the posterior section of an assembly. Starting at the top, denture tooth wear can occur, reducing its intraoral function. Denture teeth must be effectively bonded to the denture base – and this often is a problem. During the processing of denture base acrylic, porosity may arise from poor laboratory fabrication that leads to a range of problems. The denture base may become distorted by changing stress distributions on the assembly. Extrinsic acrylic discoloration often arises from staining of surface irregularities. Poor stress transfer from the acrylic to the metal mesh occurs if there is only mechanical bonding between the two materials. Finally, denture base staining often arises from microleakage along the interface of the metal mesh under the acrylic.
The materials involved have a wide range of moduli. [CLICK] Co-Cr RPD alloy (or even Au RPD alloy) has a much high modulus [CLICK] than acrylic denture teeth, acrylic denture base, or soft tissues that will ultimately accept much of the stress. Dental porcelain teeth are rarely used – but have an extremely high stiffness. [CLICK] Ideally there should not be a major difference in modulus as stress is transferred from one material to another. Otherwise, the stress tends to build up and cause failures at the boundary. To partly compensate for this problem, it is crucial to try to chemically bond the metal surfaces to the denture base acrylic if possible.
DENTURE TEETH (DT)

A. Classification:

1. Porcelain (high fusing ceramic)
2. PMMA (acrylic) – lightly crosslinked with TEGDMA
3. IPN (Interpenetrating Network) – 2-phase polymer
4. Isosit (composite; crosslinked acrylic) – heavily crosslinked
5. (Experimental [fiber-reinforced])

Denture teeth are the same types and variety as used for a complete denture. Teeth may be porcelain, PMMA, IPN, or Isosit. PMMA and IPN teeth are the most common. PMMA teeth are not as strong but are easily bonded to the denture base material. Other teeth are designed to be more wear resistant but are difficult to bond to the denture base. Porcelain teeth are slightly better in esthetics but generally not desirable for a range of other reasons.
DENTURE TEETH (DT)
DT/DB Attachment Mechanisms

B. Attachment mechanisms of DT to DB:

1. **Gross mechanical retention**
   (diatoric holes, undercuts)

2. **Micromechanical retention**
   (bur roughening, grinding, sandblasting)

3. **Pseudo-chemical bonding**
   (DB monomer penetration into DT)
   a. Minimizes interfacial leakage
      and staining (hygienic and esthetic problem)
   b. Facilitates stress-transfer
      preventing cracks or crazes near interface with base

4. **THERE IS NO CHEMICAL BONDING**

Denture tooth (DT) attachment to denture base (DB) material is usually a combination of mechanical and pseudo-chemical bonding. Gross mechanical retention occurs with undercuts, including holes (diatorics), for retention. However, this is not very good. Generally, the teeth are roughened to increase micromechanical retention as well. With PMMA teeth, it is possible for the MMA in the denture base material to be sorbed into the surface and permit chain growth from the denture base into the surface of the teeth, creating pseudo-chemical bonding (or chain entanglement). This is very strong and the ideal situation. Wear-resistant teeth (e.g., IPN or Isosit) that are made from composites have much more difficulty in developing pseudo-chemical bonding with the denture base. [CLICK] There is no true chemical bonding procedure that is possible.
DENTURE TEETH (DT)

C. Denture Tooth Wear:

1. Denture tooth vs natural tooth wearing surfaces – minimize wear
   a. [Porcelain] x [Porcelain]
   b. [Gold] x [enamel, gold, or other restorative materials (not porcelain)]
   c. [Acrylic] x [enamel, acrylic]

Denture teeth must be matched in hardness to their counterparts to insure that there is no unwanted wear occurring. Porcelain teeth should be matched with porcelain teeth. Porcelain teeth will wear natural teeth. Acrylic teeth work well against acrylic or natural teeth.
DENTURE BASES (DB)

A. Classification:

1. High-Impact Acrylic (PMMA = Lucitone 199; Lightly Xlinked)
2. Experimental (polyethylene fiber-reinforced)
3. Other (polystyrene, nylon, polycarbonate, epoxy, SS)

B. Attachment mechanisms of DB to RPD framework:

1. **Gross mechanical retention** (interpenetration of framework holes)
2. **Micromechanical retention** (roughened surface – SB)
   a. Single phase alloys cannot be effectively etched
   b. Sandblasting with Al2O3 is best
3. **NO PSEUDOChemICAL BONDING**
4. **Chemical bonding via coupling** (4-META, Silane, Rocatec)
   a. Achieve about 15-20 MPa bond strengths
   b. Discourages leakage and aids stress distribution

Denture base materials are almost always made from PMMA but have been fabricated from other polymers or reinforced materials. The denture base cannot be pseudo-chemically bonded to the metal framework but can take advantage of gross mechanical retention (i.e., holes in the metal mesh), micromechanical retention (i.e., sandblasted metal surfaces), and chemical bonding (using coupling agents and/or silicate treatments of the metal surface to facilitate chemical bonding).
DENTURE BASES (DB)

Composition of Materials

C. DB Fabrication:

1. Design considerations: avoid thin sections of acrylic near alloy

2. Curing considerations:
   a. [MMA $\rightarrow$ PMMA] = chain reaction, fast, exothermic
   b. Chain Rx = ACT (heat/BPO), INIT, PROP, TERM

3. Composition:
   a. Liquid = MMA, EGDM, HQ (Inhibitor)
   b. Powder = PMMA / PS / BMA / EGDMA, BPO, colorants, fibers (mimic arteries)

MMA is a liquid and similar to water making it unusable in that consistency. Denture base material is produced in the laboratory from a mixture of MMA and PMMA that generates a dough-like consistency which is easy to place and mold.

As shown above, a variety of modifiers are added to the mixture. The liquid normally includes ethylene glycol dimethacrylate to produce some crosslinking and limit the amount of water absorption of the denture base. HQ is an inhibitor. The powder includes polystyrene (PS), butyl methacrylate (BMA), and ethylene glycol dimethacrylate (EGDM) along with colorants and chopped nylon red fibers to mimic blood vessels. BPO is the initiator. An SEM picture of some of the powder is shown in the lower right hand corner before being mixed with MMA.
4. Manipulation of acrylic dough:
   
a. Mixing of P/L: Dissolution of monomer into surface of powder
b. Thermal decomposition of BPO on heating; Polymerization
c. New polymer becomes pseudo-chemically bonded to old polymer.

A schematic summary of the pseudo-chemical bonding between the MMA and PMMA is shown above. [CLICK] The MMA partially dissolves the surfaces of the PMMA particles and penetrates into the particles – as shown on the left. [CLICK] In the laboratory heat and pressure are applied to run the polymerization reaction. Newly growing PMMA polymer chains cross over into the PMMA particles and become entangled with pre-existing chains to generate pseudo-chemical bonding – as shown in the center. [CLICK] At the end the material is entirely PMMA.
To insure that the acrylic dough (e.g., mixture of PMMA and MMA) is well-adapted to the teeth and framework, the entire prosthesis is processed in a flask using plaster to define the remaining mold space for the acrylic resin. The mold is trial packed with acrylic dough, trimmed, repacked and then processed. There are alternative techniques but we will focus on the standard one.

What happens next depends on the properties of the methyl methacrylate monomer (MMA) which is very volatile and boils at 100°C at one atmosphere of pressure. Since the polymerization reaction is exothermic, excess heat trapped in the flask can easily raise the temperature above 100°C and cause localized boiling of the monomer which is bad. Since the polymerization reaction involves formation of a linear polymer, there are no steric problem of monomer addition to the growing chain. Almost complete reaction conversion is achieved.

There are wide range of curing cycles for denture base materials – as referenced on the chart above. A slow cycle works the best for controlling the reaction conditions and insuring that the denture base contains no defects. The conditions of temperature, time, and pressure will be discussed in detail next.
The three charts above describe differing conditions of temperature, time, pressure control for denture base processing. The vertical axis is temperature in °C. The brass metal processing flask (containing the acrylic dough, framework, teeth, plaster) is placed in a tank of heated water. A dashed line indicates the water temperature in the bath surrounding the flask. Remember that MMA boils at one atmosphere at 100°C. The horizontal axis is time in minutes.

[CLICK] In the first situation, the acrylic dough temperature rises at about the same rate as the water bath until at ~65°C, when thermal decomposition of the benzoyl peroxide initiator starts the exothermic polymerization reaction, releasing heat, and raising the internal temperature quickly to about ~135°C. This causes local boiling of some of the monomer and produces porosity throughout the denture base, particularly near the center of the acrylic mass close to the framework. This is a bad situation.

[CLICK] The second situation includes some temperature control. To partially control the effects of the exotherm, the water bath can be heated to only ~65°C so that only the exothermic heat is responsible for further temperature rises of the acrylic dough. The temperature rise stays below ~100°C but some sections may become hotter and include porosity. After the initial exotherm has happened the temperature is raised in the water bath to push the reaction to near completion.

[CLICK] In the third situation, pressure control is included as well. To completely control the effects of the exotherm, the water bath and flask are put under 2 atmospheres of pressure. That increases the boiling point for monomer to 140°C. Now, the water bath temperature can be raised quickly or slowly – without any worries that exothermic heat will induce monomer boiling. Examples of processing schedules are shown in the last figure.
DB Problems

8. Analysis of POROSITY problems:
   a. Internal porosity: P/L heterogeneity and air incorporation (spherical pores)
   b. Internal porosity: localized MMA boiling (common in thicker portions)
   c. External porosity: insufficient pressure or dough (surface blisters and pores)

9. DIMENSIONAL CHANGES on processing:
   a. Expansion on heating flask;
   b. Expansion on polymerization exotherm;
   c. Contraction on polymerization (21vol.%);
   d. Contraction on cooling to room temperature;
   e. Expansion on swelling in water;
   f. Expansion on thermal change to 32°C.

10. CRACKS and CRAZES:
    a. Created by thermal and mechanical cycling

Porosity is the major problem for denture base properties but other things may occur as well.

Internal porosity may also arise from mixing problems that create local heterogeneity or trap air. If the dough is not well packed into the mold, then insufficient pressure occurs during processing and surface blisters or pores may occur.

There are distortions of the acrylic during processing due to a wide range of temperature changes. These are itemized above. Generally it is assumed that the functioning temperature of the denture is above room temperature but below body temperature and in the range of ~32°C.

During use, the denture base and framework thermally and mechanically cycle. On the surface of the denture base there is a strong tendency to lose and gain water at the same time. This may produce crazes and cracks that will affect the esthetics and pick up stain.
Maintenance of Acrylic Portions

D. DB reprocessing:

1. Hard and soft tissue changes every 5-8 years require modifying denture base:
   a. Relining = resurfacing of the tissue surface
   b. Rebasing = replacement of entire denture base

2. Soft-liners generally not practical

E. DB hygiene:

1. Clean with toothbrush and warm soap-and-water
2. Avoid oxidizing or Cl-containing materials
3. Diligently clean both the top and tissue-borne surfaces

Acrylic portions of complete dentures or RPDs may require repair or replacement for a variety of reasons. Generally hard and soft tissue changes under the denture base lead to poor adaptation and require adjustments. Relining produces a new palatal surface that is properly adapted. Rebasing is the complete replacement of the denture base. With complete dentures, soft liners are often used to manage conditions of changing soft tissues or irritation problems. However, these are too complicated to be used with RPDs since there is little space between the framework and palatal surface to add soft liners into the design. If the acrylic thickness is too small then it tends to fracture.

Patients often are confused about what they can utilize to clean an RPD since there are so many different materials involved. The best solution is to use a soft brush with soap and warm water. Avoid using anything that will attack the casting alloy or acrylic.
Thank you.