Fixed Prosthodontics

Collected and organized by
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Acknowledgments

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The course includes the preclinical procedures for crown and fixed partial denture construction and their interdependence procedures will be stressed. This course will include the preclinical procedures for crown and fixed partial denture construction and their interdependence procedures will be stressed. The candidate will learn the basic laboratory steps for fixed prosthodontics including working cast construction, wax pattern fabrication, investing, casting and fabrication of provisional restoration.

**Core Knowledge**

By the end of this course, students should be able to:
- Identify different types of fixed restorations.
- Understand principles behind fabrication of fixed restorations including waxing, investing, casting and finishing
- Describe different pontic designs.
- Understand casting defects and how to avoid them.
- Identify different types of all ceramic restorations and the rationale behind using them.
- Explain theory and techniques behind porcelain fused to metal restorations
- Describe soldering and welding techniques

**Core Skills**

By the end of this course, students should be able to:
- Be aware of important terminology.
- Distinguish different types of fixed dental restorations.
- Apply principles learned of multiple laboratory techniques for fabrication of different fixed dental restorations.
- Assess problems that arise during laboratory procedures.
- Work efficiently within a team.
- Practice independent learning by using information technology tools.
- Evaluate information from various standard sources to improve professional skills.

## Course Overview

<table>
<thead>
<tr>
<th>ID</th>
<th>Topics</th>
<th>Interactive Lecture</th>
<th>Field Work</th>
<th>Class Assignments</th>
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<th>Lab</th>
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<td>1</td>
<td>Introduction and types of crown and fixed partial denture</td>
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<td>8</td>
<td>Casting defects</td>
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<td>Soldering and welding</td>
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<td>Porcelain fused to metal restorations</td>
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**TOTAL HOURS (60)**: 24, 7, 5, 24
Chapter 1
Introduction to Fixed Prosthodontics

Objectives
- Provide an overview on fixed prosthodontics.
- List important terms related to fixed prosthodontics.

An overview on fixed prosthodontics

**Prosthesis:**
It is an artificial replacement of an absent part of the human body.

**Dental prosthesis:**
It is an artificial replacement of one or more teeth (up to the entire dentition) and associated structures.

**Prosthodontics:** It is subdivided into: (Error! Reference source not found. 1)
- **Removable prosthodontics.**
- **Fixed prosthodontics:** The branch of prosthodontics concerned with the replacement and/or restoration of teeth by artificial substitutes that not readily removed from the mouth.

Fig. 1. Fixed versus removable prosthodontics.
Crown

An artificial replacement that restores missing tooth structure by surrounding part or all of the remaining structure with a material such as cast metal, porcelain, or a combination of materials such as metal and porcelain.

Fixed partial denture

Any dental prosthesis that is luted, screwed or mechanically attached or otherwise securely retained to natural teeth, tooth roots, and/or dental implant abutments that furnish the primary support for the dental prosthesis.

Components of the fixed partial denture: (Error! Reference source not found. 2)

- **Pontic:**
  It that part which acts as the actual substitute for the lost tooth and is suspended between the retainers replacing the lost natural tooth functionally and esthetically.

- **Retainer:**
  It is that part which rebuilding the prepared tooth and by the means of which the pontic is attached to the abutment tooth.

- **Connector:**
  It is that part uniting the pontic with retainer (i.e. joining the component parts). It may be rigid (cast, soldered or welded) or non-rigid connector.

Abutment tooth: It is the natural tooth which supports and retains the fixed partial denture.

![Fig. 2. Components of fixed partial denture.](image-url)
**Resin-bonded restorations**

A fixed dental prosthesis that is luted to tooth structures which has been etched to provide mechanical retention for the resin cement. *(Error! Reference source not found. 3)*

![Fig. 3. Resin-bonded prosthesis (Rochette design).](image)

**Radicular retained restoration**

It consists of a post with an attached core that obtains its retention and resistance from prepared root portion of an endodontically treated tooth. While the root preparation retains the post, the core establishes retention and resistance for a crown that restores the tooth to normal form and function. *(Error! Reference source not found. 4)*

This post and core may be custom-made or prefabricated.

![Fig. 4. Custom-made post, core and the crown for endodontically treated tooth.](image)
Chapter 2
Types of Crowns and Fixed Partial Dentures

Objectives
- Identify the types of crown restorations.
- Identify the types of fixed partial dentures.

Classification of fixed prosthodontic restorations

<table>
<thead>
<tr>
<th>Classification crowns</th>
<th>Retained mainly by:</th>
</tr>
</thead>
<tbody>
<tr>
<td>I- Full veneer crown</td>
<td>• Grooves</td>
</tr>
<tr>
<td>a. Encircling the tooth</td>
<td></td>
</tr>
<tr>
<td>- Metallic: e.g., complete cast metal crown</td>
<td></td>
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<tr>
<td>- Nonmetallic: e.g., all-ceramic crown</td>
<td></td>
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<tr>
<td>- Combined: e.g., metal-ceramic crown</td>
<td></td>
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<tr>
<td>b. Post in the root canal</td>
<td></td>
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<tr>
<td>c. Retained by both methods</td>
<td></td>
</tr>
<tr>
<td>II- Partial veneer crown</td>
<td>• Pins</td>
</tr>
<tr>
<td>Retained mainly by:</td>
<td></td>
</tr>
<tr>
<td>• Grooves</td>
<td></td>
</tr>
<tr>
<td>o Three-quarter crown</td>
<td></td>
</tr>
<tr>
<td>o One-half crown</td>
<td></td>
</tr>
<tr>
<td>o Seven-eighth crown</td>
<td></td>
</tr>
<tr>
<td>o MacBoyle crown</td>
<td></td>
</tr>
<tr>
<td>• Pins</td>
<td></td>
</tr>
<tr>
<td>• Combined means of retention</td>
<td></td>
</tr>
<tr>
<td>o Include both grooves and pins</td>
<td></td>
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</tbody>
</table>
Complete veneer crown: A restoration that covers all the coronal tooth surfaces (mesial, distal, facial, lingual, and occlusal). (Error! Reference source not found. 5)

![Fig. 5. A full veneer crown.](image)

Partial veneer crown: A restoration that restores all but one coronal surface of a tooth, usually not covering the facial surface. (Error! Reference source not found. 6)

![Fig. 6. A partial veneer crown (three-quarter crown).](image)

Three-quarter crown: Restore the occlusal surface and three of the four axial surfaces (not including the facial surface). (Error! Reference source not found. 6)

Reverse three-quarter crown: Restore all surfaces except the lingual surface.

Seven-eighth crown: A three-quarter crown extended to include a major portion of the facial surface except the mesio-buccal cusp of maxillary molars. (Error! Reference source not found. 7)
**One-half crown:** Modification from three-quarter crown which restores the occlusal and mesial surfaces as well as portions of the facial and lingual surfaces. *(Error! Reference source not found. 8)*

**Pinledge retainer:** It is a modification of anterior three-quarter crown preparation to obtain retention and resistance from long parallel pens in the lingual surface of the clinical crown. *(Error! Reference source not found. 9)*
**Laminates:** Are veneer restorations that restore the facial surface of a tooth for esthetic purposes. It is fabricated from resin or ceramic and bonded to etched enamel with resin cement. *(Error! Reference source not found. 10)*

![Fig. 10. Laminate veneer.](image)

**Inlay retainer:** It is an intra-coronal restoration that restores the proximal and occlusal surfaces but not cover the cusps entirely. *(Error! Reference source not found. 11)*

![Fig. 11. Inlay restoration.](image)

**Onlay retainer:** It is a modification of the inlay with cusp overlays on the occlusal surface to protect the integrity of the remaining tooth structure. *(Error! Reference source not found. 12)*

![Fig. 12. Onlay restoration.](image)
# Classification of Fixed Partial Denture

<table>
<thead>
<tr>
<th>1) According to design</th>
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<tbody>
<tr>
<td>Simple fixed partial denture</td>
<td>Ø Fixed-fixed</td>
</tr>
<tr>
<td></td>
<td>Ø Fixed-supported</td>
</tr>
<tr>
<td></td>
<td>Ø Cantilever</td>
</tr>
<tr>
<td></td>
<td>Ø Spring cantilever</td>
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<td></td>
<td>Ø Removable</td>
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<tr>
<td>Compound fixed partial denture: employing more than one of the above types</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>2) According to material</th>
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<tbody>
<tr>
<td>Metallic:</td>
<td></td>
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<tr>
<td></td>
<td>Ø High noble alloy</td>
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<tr>
<td></td>
<td>Ø Noble alloy</td>
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<tr>
<td></td>
<td>Ø Base metal alloy</td>
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<tr>
<td>Nonmetallic:</td>
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<tr>
<td>All-ceramic</td>
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<td>Combined:</td>
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<tr>
<td>Metal-ceramic</td>
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<tr>
<th>3) According to site</th>
<th></th>
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<tbody>
<tr>
<td>Anterior</td>
<td>Ø Unilateral</td>
</tr>
<tr>
<td></td>
<td>Ø Bilateral</td>
</tr>
<tr>
<td>Posterior</td>
<td>Ø Complex: anterior and posterior segments involving the canine</td>
</tr>
</tbody>
</table>

**Fixed-fixed bridge:** It is a fixed partial denture where the retainers and pontics are all soldered together. It is cemented at both ends to the abutment teeth. *(Error! Reference source not found. 13)*

**Fixed-supported bridge:** It is a fixed partial denture which is not actually joined to one end of the abutment teeth but connected to it by means of a non-rigid connector allowing some individual movement of the abutment teeth. *(Error! Reference source not found. 14)*
**Fixed-free (cantilever) bridge:** It is a fixed partial denture where the pontic is fixed to and derived its support from one or double retainers at one end only while the other end is unsupported. *(Error! Reference source not found. 15)*

**Spring cantilever bridge:** It is a cantilever fixed partial denture where the pontic is at the end of resilient curved arm deriving its support from an abutment remote from the edentulous space. *(Error! Reference source not found. 16)*

**Removable bridge:** It is a fixed partial denture where each retainer consists of two parts, one fixed to the abutment tooth and one soldered to the pontic. It can be removed for cleansing purposes.

**Simple bridge:** It is a one single type bridge which may be fixed-fixed or fixed-supported or fixed-free or spring cantilever or removable bridge.
**Compound bridge:** It is a combination type composed of two or more of the simple types.

**Unilateral bridge:** It is the two or three teeth anterior bridge which does not cross the midline.

**Bilateral bridge:** It is the three or four teeth bridge which involves teeth on both sides of midline.

**Complex bridge:** It is a bridge that extends from one of its terminals beyond the canine.

**Immediate fixed partial denture:** It is a fixed partial denture with root extension pontic and is constructed before extraction of the tooth and seated in position immediately after the extraction at the same visit.
Chapter 3
Working Casts and Dies

Objectives
• Identify the working cast and dies.
• Identify the available die materials.
• Describe the die system.
• Describe the die preparation.

Requirements of good casts and dies

The working cast is the replica of the prepared teeth, ridge areas, and other parts of the dental arch.

The die is the positive reproduction of the prepared tooth and consists of a suitable hard substance of sufficient accuracy (usually an improved stone, resin, or metal).

The cast must meet certain requirements:
1. It must reproduce both prepared and unprepared tooth surfaces.
2. The unprepared teeth immediately adjacent to the preparation must be free of voids.
3. All surfaces of any teeth involved in anterior guidance and the occlusal surfaces of all unprepared teeth must allow for precise articulation of the opposing casts.
4. All relevant soft tissues should be reproduced in the working cast, including all edentulous spaces and residual ridge contours that will be involved in the fixed prosthesis.

The die for the fixed restoration must meet certain requirements:
1. It must reproduce the prepared tooth exactly.
2. All surfaces must be accurately duplicated, and no bubbles or voids can be accepted.
3. The remaining unprepared tooth structure immediately cervical to the finish line should be easily discernible on the die, ideally with 0.5 to 1 mm visible (enough must
be present to help the technician establish the correct cervical contour of the restoration).

4. Adequate access to the margin is imperative.

### Die materials

Requirements of die materials:

1. Should have high mechanical strength properties to withstand handling without being fractured or destroyed.

2. Should have surface hardness to resist scratching and abrasion while the wax pattern is being formed.

3. Should have high stability and excellent dimensional accuracy.

4. Should be compatible with the impression materials.

5. Should have good color contrast with other materials so that the preparation margins can be easily detected.

6. Should be compatible with the separating medium that may be used.

Materials available for construction of die material can be classified into:

A. **Stone die**

   Gypsum can be mixed by:
   - Hand mixing
   - Mechanical mixing under vacuum

   Advantages of stone die:
   - Dimensional accuracy
   - Surface detail reproduction is acceptable with Type IV and Type V gypsum products
   - Inexpensive
   - Easy to use

   Disadvantages:
   - Poor resistance to abrasion.

   To overcome its poor resistance to abrasion:

   i. The use of “gypsum hardeners” e.g., colloidal silica
ii. Impregnate the surface of the die with a low-viscosity resin e.g., cyanoacrylate

iii. The use of resin-strengthened gypsum products such as ResinRock (Whip Mix: USA)

B. Amalgam die
C. Acrylic or epoxy die
D. Refractory die (ceramic die)
E. Electroplated die (Silver plated - Copper plated)
F. Flexible die

Methods available for construction of working casts and dies

Available die systems:
1. Working cast with a separate die (multiple-pour technique).
2. Working cast with removable die:
   a) Dowel Pin technique
   b) Di-Lock Tray technique
   c) Pindex System
   d) DVA Model System
3. The single die technique that was used with single copper band impression made of either impression compound or rubber base.

Working cast with a separate die

The impression is disinfected and poured in type IV or V stone in the area of preparation only. After stone setting, a second pour is made of the entire arch (sometimes, a third pour is obtained if an extra die is needed for polishing). (Error! Reference source not found. 17)

The first pour, the most accurate, is trimmed into a die with a handle and used for the wax pattern construction. The complete arch cast is mounted on an articulator.
Fixed Prosthodontics

Advantages:
1. Simplicity and no need for special equipments.
2. Slightly more accurate because it keeps the relationship between abutments fixed and immovable which is necessary for fabrication fixed partial denture.
3. Requires only minimum trimming.
4. The gingival tissue and other landmarks are intact so it is easier to obtain harmonious contours of the wax pattern.

Disadvantages:
1. The wax pattern must be transferred from the separate die to the cast so distortion of the wax pattern may result.
2. It is difficult to transfer complex or fragile wax patterns from die to cast.
3. Seating the pattern on the master cast may be problematic because the second pour of many impression materials is slightly larger than the first.
4. The technique can be used only with elastomeric impression materials.

Working cast with a removable die

The removable die system should satisfy these requirements:
- The dies must return to their exact original positions.
- The dies must remain stable, even when inverted.
- The cast containing the dies must be easy to mount on an articulator.

Fig. 18. Working cast with three separate dies
Several methods can be employed to allow the repositioning of a die in its working cast. Most of these devices can either be oriented in the impression before it is poured (pre-pour technique) or attached to the underside of a cast that has already been poured (post-pour technique). A tapered, flat-sided brass dowel pin can be used to orient the die of the prepared tooth into the working cast before pouring or after. (Error! Reference source not found. 18)

**Dowel pen system (pre-pouring)**

**Technique:**
- A dowel pin is positioned over each prepared tooth in the impression. A number of items can be used for orienting dowels: needles, paper clips, bobby pins and paper matches. (Error! Reference source not found. 19)

Fig. 18. Types of anti-rotational devices used for removable dies; A) flat sided single dowel, B) single curved dowel, C) double straight dowel with common head, D) two separate parallel dowel and E) keyed plastic outer tray.

Fig. 19. Dowel pins are positioned over the impression with bobby pins.
- Pour mixed stone into the impression, filling the impressions of the teeth and covering the serrated end of the dowel pin.

- When the stone has set, remove the bobby pins. Place a small ball of soft utility wax on the tip of each dowel. Then, lubricate the stone around each dowel with a thin coat of separating medium. *(Error! Reference source not found. 20)*

![Fig. 20. The stone around the dowel pin is lubricated.](image)

- Pour the base. After the stone has set, remove the cast from the impression and trim the excess on a model trimmer. Use a sharp knife to remove the spheres of utility wax. *(Error! Reference source not found. 21)*

![Fig. 21. The end of the dowel is located.](image)

- When the stone is hard and dry, use a saw frame with a thin blade to cut through the layer of die stone. The cut on the mesial and distal side of each die should taper toward each other slightly from occlusal to gingival. *(Error! Reference source not found. 22, 23)*
- Die trimming.

**Dowel pen system (post-pouring)**

The dowel can be cemented into holes drilled into the flat underside of a cast that has already been poured. *(Error! Reference source not found. 24, 25)*

Fig. 22. A thin blade is used to cut through the first pour.

Fig. 23. The cuts should taper from occlusal to gingival.

Fig. 24. Holes are drilled into the underside of the cast and keyed with acrylic bur.

Fig. 25. The head of the dowel is seated into cement-lined hole.
**Pindex system**

It is a post-pouring technique. The impression is poured without positioning and attaching dowel pins. The machine accurately drills parallel holes from the underside of a trimmed cast. *(Error! Reference source not found. 26)*

**Technique:**

- Pour the impression in the usual manner and add 20 mm of stone beyond the edge of the tray.
- Use a model trimmer to trim the cast.
- Use a pencil to mark the desired location of the pins on the occlusal surfaces of the teeth or preparations. There should be two pins for each die, two for each edentulous area, and two pins in each terminal segment containing unprepared teeth. *(Error! Reference source not found. 27)*
- Switch on the machine and drill the pin holes. *(Error! Reference source not found. 28)*
Apply a small amount of cement to the end of each pin and cement it. (Error! Reference source not found. 29)

Apply a thin coat of separating medium to the bottom of the cast.

The second pour is done using type III stone to form the base of the cast.

Sectioning of the cast into dies. (Error! Reference source not found. 30)

Die trimming.
Di-lok tray system

A snap-apart tray with internal orienting grooves and notches is used to reassemble the working cast and die. (Error! Reference source not found. 31)

DVA system and Zeiser system

These systems use a precision drill and special baseplates that are aligned and drilled to provide die removal. These methods offer the advantage of allowing for the expansion of stone which is relieved by the saw cuts. (Error! Reference source not found. 32)
Die trimming

Trim away excess stone gingival to the finish line. Bulk trimming is done using large acrylic trimming bur. Then, area adjacent to finish line is trimmed with a blade. Finally, mark the finish line with the red pencil. (Error! Reference source not found. 33)

Fig. 33. Die trimming.
Chapter 4
Fabrication of Wax Pattern

Objectives

• Identify the good casting wax.
• Describe the basic preparation steps before waxing.
• Describe the primarily steps for wax pattern construction.
• Describe the evaluation of a good wax pattern.

Casting wax

Requirements of a good casting wax:

1. It must flow readily when heated, without chipping, flaking, or losing its smoothness.
2. When cooled, it must be rigid.
3. It must be capable of being carved precisely, without chipping, distorting, or smearing.

The American Dental Association (ADA) has categorized waxes into two types:

   Type I: Medium wax (used with the direct technique in the oral cavity).
   Type II: Soft wax (used for the indirect technique).

During wax handling, Stresses occur as a result of the heating and manipulation. Wax (as a thermoplastic material) "relaxes" as these stresses are released. The result is distortion. To minimize this distortion, patterns should never be left off the die and should be invested as soon as possible after fabrication.

Also, wax has memory which means that it exhibits some elasticity unless it is thoroughly liquefied. This problem can be overcome by applying the initial layer of wax in melted increments or the initial copping can be made by dipping in melted wax).
Correction of defects

Small dimple in the die can be blocked on the working die, as long as the defect does not extend to within 1 mm of the margin, using zinc phosphate cement or other commercial products. *(Error! Reference source not found. 34)*

![Fig. 34. Blocking the defects on the working die.](image)

Marking the margins

The location of the cavo-surface margin is marked with colored graphite-free pencil. *(Error! Reference source not found. 35)*

The color of the pencil should contrast the color of the wax used (i.e. red pencil can be used for a green wax).

The ordinary lead pencil is not recommended because:

- it can abrade the die
- traces of graphite can prevent complete casting
- its darker color can interfere with achieving proper adaptation at the margin

![Fig. 35. The preparation margin is marked with graphite-free pencil.](image)
Provision of adequate cement space

Cement space (20-40 μm for each wall) should exist between the internal surface of the casting and the prepared tooth except immediately adjacent to the margin.

This space provides room for luting cement and allows complete seating of the restoration during cementation.

If the cement space is too narrow, the casting will not seat properly during cementation. If the cement space is too wide, the casting will be loose on the tooth.

Factors increasing the cement space:

1) Use of solid cast with separate die.
2) Use of die spacer.
3) Use of initial layer of soft wax.
4) Increased expansion of the investment mold.
5) Removal of metal from the fitting surface.

Factors reducing the cement space:

1) Use of resin or electroplated die.
2) Use of casting alloys with a higher melting range.
3) Reduced expansion of the investment.

Die spacer

It is a material similar to airplane paint applied on the surface of the die to increase the cement space between the restoration and the prepared tooth. It is formulated to maintain a constant thickness when painted on the die (NOT coat the entire preparation but, a band of 1 mm near the margin must be left unpainted). (Error! Reference source not found. 36)
Wax pattern fabrication

Waxing instruments

Waxing instruments can be categorized according to intent of its use:

- Wax addition instruments.
- Wax carving instruments.
- Wax burnishing instruments.

PKT waxing kit is a popular waxing instrument designed by Dr. Peter K. Thomas specifically for the wax additive technique. *(Error! Reference source not found. 37)*

* no.1 and no. 2 are wax addition instrument
* no. 3 is a burnisher is a burnisher for refining occlusal anatomy
* no. 4 and no. 5 are wax carvers

Fig. 36. Die spacer application (must be kept 1 mm away from the margin).

Fig. 37. PKT waxing instruments.
Electric waxing instrument: *(Error! Reference source not found. 38)*

It allows precise temperature control of the wax which is important for proper manipulation and carbon buildup can be kept to a minimum.

![Electric waxing instrument](image)

**Fig. 38. Electric waxing instrument.**

### Coping fabrication

- Coat the die with die lubricant and allow it to soak in for several minutes.

- Flow wax over the surface of the preparation on the die, using quick strokes of a hot wax spatula. Dipping the die into wax is another method can be used for developing a uniform and thin initial coping of wax. *(Error! Reference source not found. 39)*

![Initial coping fabrication](image)

**Fig. 39. Initial coping fabrication.**

- For removal of the coping, a constant grip is maintained on the pattern by thumb and forefinger of one hand while pressure is applied against them with the thumb and forefinger of the other hand which also holds the die. *(Error! Reference source not found. 40)*

- Evaluation of the initial coping. The pattern is rotated under bright light and look for shadows formed by folds or creases. Magnification (ten power magnification) loops is very helpful.
Axial Contours

**Location of proximal contacts:**

- For posterior teeth, located in the occlusal third of the crowns except for the contacts between the maxillary first and second molars which are located in the middle third.

- For posterior teeth, located slightly to the facial aspect of the middle except for the contacts between maxillary first and second molars which are generally centered facio-lingually. *(Error! Reference source not found. 40, 41)*

- Occluso-gingivally, the contact must be more than just a point but it must not extend far enough cervically to encroach on the gingival embrasure. *(Error! Reference source not found. 42)*

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Fig. 40. Location of the proximal contacts. (A), on maxillary teeth; (B), mandibular teeth.

Fig. 41. Facio-lingual dimension of the proximal contacts; A) correct, B) too broad, C) too narrow.

Fig. 42. Occluso-gingival dimension of proximal contacts; A) correct, B) too large, C) too small.
The axial surface of the wax cervical to the proximal contact:

- Should be flat or slightly concave.

The height of contour on the facial surface of posterior teeth

- Usually occurs in the cervical third. It also occurs in the cervical third on the lingual surface of maxillary premolar and molars; but on mandibular teeth, it occurs in the middle third.

Emergence Profile

- The part of the axial contour that extends from the base of the gingival sulcus past the free margin of the gingiva and extends to the height of contour producing a straight profile in the gingival third of the axial surface. (Error! Reference source not found. 43)

Occlusal Morphology

The occlusal scheme can be classified by the location of the occlusal contact made by the functional cusp on the opposing tooth in centric relation: (Error! Reference source not found. 44, 45)

- Cusp-fossa
- Cusp-marginal ridge
Margin Finishing

Remove the pattern from the working cast and place it back on the freshly lubricated die. Make certain that the red line on the die finish line is still distinct. Smooth any roughness on the axial surfaces with a slightly warm beavertail burnisher. Re-melt the entire marginal periphery.

Evaluation

Remove the pattern from the working cast and perform final evaluation. *(Error! Reference source not found. 46)*

Fig. 46. Removal of the wax pattern.
Check the margin carefully for the following discrepancies:

* Over-waxed margins
* Short margins
* Ripples
* Thick margins
* Open margins
**Objectives**

- Identify different types of pontics.
- Describe the proper design of pontics.
- Identify the finish line and its configuration.

### Pontic Design and Finish Lines

<table>
<thead>
<tr>
<th>Pontic design</th>
<th>Mucosal contact</th>
<th>Non-mucosal contact</th>
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<tr>
<td></td>
<td>Ridge-lap</td>
<td>Sanitary (hygienic)</td>
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<tr>
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<td>Modified sanitary (hygienic)</td>
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<td></td>
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<tr>
<td></td>
<td>Conical</td>
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**Sanitary (hygienic) pontic** *(Error! Reference source not found. 47)*

- A non-mucosal contact pontic.
- It is used in nonappearance zone (mandibular molars).
- Made of metal.
- Advantage: it allows good access for oral hygiene.
- Disadvantage: poor esthetic and food entrapment.
- Contraindication: Where esthetic is important and minimal occluso-gingival dimension.

**Modified sanitary (hygienic) pontic** *(Error! Reference source not found. 48)*

- It is a modified version of sanitary pontic where it gingival portion is shaped like an archway between the retainers.
Ridge-lap (Saddle) pontic

- It has a concave fitting surface that overlap the residual ridge bucco-lingually. (*Error! Reference source not found. 49*)
- It should be avoided because the concave gingival surface of the pontic is not accessible to cleaning with dental floss which lead to plaque accumulation and tissue inflammation.

Modified ridge-lap

- This design gives the illusion of a tooth and combines the best features of the hygienic and saddle pontic designs. (*Error! Reference source not found. 50*)
- Its gingival side must have no depression or hollow and should be as convex as possible.
- Its tissue contact resembles a letter T.
- Indication: it is used in area with esthetic concern (maxillary and mandibular anterior teeth - maxillary premolars and molars).
- Materials: metal-ceramic and all-ceramic.
Conical pontic

- Also, called egg-shaped, bullet-shaped or hear-shaped.
- It should be made as convex as possible with only one point of contact at the center of the residual ridge. (Error! Reference source not found. 51)
- This design is not suitable with broad ridge because it has a small tip in relation to the overall size of the pontic with a tendency to collect food debris.
- Indications: it is recommended for the replacement of mandibular posterior teeth.
- Materials: all-metal - metal-ceramic - all-ceramic.

Ovate pontic

- It is the most esthetically appealing pontic design.
- It has a convex tissue surface resides in the soft tissue depression or hollow in the residual ridge which makes it appear that a tooth is emerging from the gingiva. (Error! Reference source not found. 52)
- Disadvantage: it requires surgical preparation.
- Indication: maxillary anterior and premolars.
- Materials: metal-ceramic - all-ceramic.
Finish line

Finish line:

Line of demarcation between prepared and unprepared tooth structure. *(Error! Reference source not found. 53)*

Ideal finish line should be:

1. Easily prepared without overextension or unsupported enamel.
2. Easily identified in the impression and on the die.
3. Conservation of tooth structure.
5. Sufficient bulk for the material.
Types of finish line:

- **Feather edge margin.** *(Error! Reference source not found. 54)*
  
  It should be avoided because:
  
  - It fails to provide adequate bulk at the margin.
  - Overcontoured restoration often results.

- **Chisel edge margin.** *(Error! Reference source not found. 55)*
  
  It is a variant of the featheredge margin and is formed when there is a larger angle between the axial surfaces and the unprepared tooth structure.

- **Chamfer margin.** *(Error! Reference source not found. 56)*
  
  It is recommended for cast metal restoration and metal portion (lingual) of metal-ceramic restoration.

  It is distinct, easily identified, provide room for adequate bulk of the material and can be prepared with precision.

  It is prepared with tapered diamond with a rounded tip held parallel to the long axis of the tooth.
- **Shoulder margin.** *(Error! Reference source not found. 57)*
  It is recommended for the facial part of metal-ceramic restoration (porcelain margin) and all-ceramic restoration. It is prepared using tapered diamond with a flat end. It should form 90-degree angle with the unprepared tooth surface. Its main disadvantage is less conservative of tooth structure.

- **Shoulder with bevel.** *(Error! Reference source not found. 58)*
  It is recommended for the facial surface of metal-ceramic restoration where the metal collar is used.

- **Sloped shoulder.** *(Error! Reference source not found. 59)*
  It is recommended as an alternative for 90-degree shoulder.
Chapter 6
Spruing and Investing

Objectives

- Identify the spring methods.
- Describe proper formation of spruing system.

Spruing

There are three basic requirements of spruing:

1) The sprue must allow the molten wax to escape from the mold.
2) The sprue must enable the molten metal to flow into the mold with as little turbulence as possible.
3) The metal within it must remain molten slightly longer than the alloy that has filled the mold.

Spruing methods (direct versus indirect spruing)

Direct spruing
- One end of the straight sprue former is attached to the thickest part of the wax pattern and the other end is secured to the crucible former. *(Error! Reference source not found. 60)*
- Placing a ball reservoir to supply molten metal needed to fill the pattern areas completely.
- It is used for single units and for small multiple-unit patterns.
- Advantage:
  - Simple than indirect spruing.
  - Require less time and effort.
Disadvantage:
- Suck-back porosity.

Indirect spruing
- The sprue formers are used to attach wax patterns to the superior surface of a runner bar. *(Error! Reference source not found. 61)*

Advantages:
- Greater predictability and reliability in castings.
- Enhanced control of casting porosity.

Sprue former location
The sprue former should be attached to the thickest cross-sectional area of the pattern away from the margins and occlusal contacts.

The area of attachment must be smooth and uniform without sharp edges.

Sprue former gauge
A sprue former of sufficient gauge should be selected to supply the volume of alloy required by the patterns to be cast. A sprue former that is thicker than the thickest portion of the wax pattern should be used to permit solidification of the metal in the casting prior to the sprue and button. (Error! Reference source not found. 62)

In some casting techniques other than the commonly used centrifugal technique, a narrow sprue is essential. With air-pressure machines, the melt is made directly in the depression created by the crucible former and then forced into the mold by the sudden change in air pressure. With this technique, a narrow sprue prevents the molten metal from flowing into the mold prematurely.

**Sprue former length**

With direct spruing: the sprue formers should be long enough to position the wax patterns outside the heat center of the investment ring.

With indirect spruing: the pattern should be placed off the runner bar in a location just outside the heat center of the investment. (Error! Reference source not found. 63)

A distance of 6-8 mm should be left between the end of the casting ring and the wax pattern in case of gypsum-bonded investment and 3-4 mm in case of phosphate-bonded investment. This position permits gas escape from the mold and prevents fracture of the investment during casting. (Error! Reference source not found. 64)
Orientation of the wax pattern
Do not create sharp 90-degree angles between the sprue former and the wax pattern.

Location of the reservoir
The reservoir system should be placed in the heat center of the ring to permits the reservoir to remain molten long enough to furnish metal to the patterns until completely solidifies. *(Error! Reference source not found. 63)*

Sprue former composition
Different types of sprue former according to the material:

Wax: It is preferred for most castings because it melts at the same rate as the pattern and thus allow easy escape of the molten wax.

Plastic: It softens at a higher temperature than the wax pattern which tend to undergo greater expansion before softening than does wax

Metallic: It is removed from the investment at the same time as the crucible former.

Investing

Purpose:

⇒ To provide the mold for the molten metal.

⇒ To conform to the thermal expansion of the metal during heating.

Shrinkage Compensation:
There are four mechanisms that can play a role in producing an expanded mold:

1. Setting expansion of the investment.
2. Hygroscopic expansion.
3. Wax pattern expansion.
4. Thermal expansion.

**Casting ring and liner**

The casting ring holds the investment in place during setting and restrict the expansion of the mold. *(Error! Reference source not found. 65)*

The casting ring may be rigid or flexible, round or oval in shape, or may be split ring.

**Liner material:**

- Asbestos: it was used for many years but it was removed from the market because of concern over its carcinogenic properties.

- Ceramic paper is now used as substitutes for asbestos. It does not readily absorb water except under vacuum.

- Cellulose paper is now used as substitutes for asbestos. It does absorb water & in doing so becomes thicker and more compressible.

**Vacuum mix, vacuum pour technique**

- Place the assembled ring and crucible former into the hole at the top of the vacuum mixer. *(Error! Reference source not found. 66)*
- Connect one end of the vacuum tubing to the vacuum outlet on the vacuum mixer. Insert the metal connector on the other end of the tubing into the hole in the lid. Turn on the vacuum. *(Error! Reference source not found. 67)*

![Fig. 67. Tubing is connected for investing.](image)

- Pour the recommended amount of water into the bowl. Add a package of investment to the water and mix it with a spatula until all of the investment has become wet. *(Error! Reference source not found. 68)*

![Fig. 68. Hand spatulation.](image)
- Turn on the machine and power spatulation for 15 seconds. (*Error! Reference source not found. 69*)

![Fig. 69. Power spatulation.](image)

- Do not turn off the vacuum and do not disconnect the vacuum at this point until the investment has run to the lower side of the bowl. (*Error! Reference source not found. 70*)

![Fig. 70. Starting position for pouring investment into the ring.](image)

- Slowly invert and continue fill the ring. (*Error! Reference source not found. 71*)
- Remove the casting ring and crucible former the machine.

**Brush technique (vacuum mixing, hand pouring)**

- Add investment powder to the liquid in the mixing bowel and quickly incorporate it by hand.
- Attach the vacuum hose to the bowel, evacuate the bowel and mechanically spatulate.
- Coat the entire pattern with investment, pushing the material ahead of the brush from a single point. Gently vibrate throughout the application of investment.
- Place the lined casting ring over the pattern and with the aid of vibration, pour the investment down the side of the ring. Fill the ring slowly starting from the bottom and moving up.
- When the investment reaches the level of the pattern, tilt the ring several times to cover and uncover the pattern to minimize the possibility of entrapment of air.
- After the ring is filled to the rim, allow the investment to set. And if the hygroscopic technique is used, the ring is placed in water path for 1 hour.

**Ringless investment technique**

The ringless technique has become popular and used with the phosphate-bonded investment. The plastic ring is removed before the invested pattern is placed into the burnout oven.

It uses a paper or plastic casting ring and is designed to allow unrestricted expansion. Also, this technique allows easier escape of gases from the mold during casting.
Chapter 7

Casting Procedures

Objectives

- Identify the importance of wax elimination.
- Identify the heat source for casting.
- Identify the casting force.
- Recognize the difference between casting machines.

Wax elimination (or burnout)

Wax elimination (or burnout) consists of heating the investment in a thermostatically controlled furnace until all traces of the wax are vaporized. The temperature should be maintained long enough (heat soak) to minimize a sudden drop in temperature upon removal from the oven.

Casting machines

A casting machine requires:

- A heat source to melt the alloy.
- A casting force.

Heat source

It can be either:

1) Reducing flame of a torch

   There are two types of torch tips to choose from:

   ⇒ Single-orifice tip
- It concentrates more heat in one area but the area of heat is smaller than that produced by the muti-orifice tip.

⇒ Muti-orifice tip
- It is preferred for metal-ceramic alloys.
- Advantage: The distribution of heat over a wide area for more uniform heating of the alloy.

Choice of fuels:
Three fuel sources could be used to melt metal-ceramic alloys:
- Acetylene
- Natural gas
- Propane

Conventional alloys can be melted with a gas-air torch but the metal-ceramic alloys in a higher melting range need a gas-oxygen torch. Base metal alloys need a multi-orifice gas-oxygen or oxyacetylene torch. (Error! Reference source not found. 72)

During the adjustment of the torch: (Error! Reference source not found. 73)
1. 1st zone (mixing zone): It is a cool, colorless one.
2. 2nd zone (combustion zone): It is a greenish-blue combustion zone in which partial combustion takes place.
3. 3rd zone (reducing zone): Next is a dim blue tip. This is the hottest area in the flame and is the only part of the flame used to heat the casting alloy.
4. 4th zone (oxidizing zone): It is another oxidizing zone in which final combustion between the gas and surrounding air occurs.

2) Electricity

Electric heating can occur by:

- Convection from a heating muffle
- Generation of an induction current in the alloy

**The casting force**

Present-day casting machines still use either air pressure or centrifugal force to fill the mold. *(Error! Reference source not found. 74)*

Some machines evacuate the mold before it is filled with metal, and vacuum has been shown to improve mold filling.

Casting crucibles:

a. High-heat crucibles
b. Clay crucibles
c. Carbon crucibles
Casting base metal alloys

- Place the investment ring in a cold burnout oven and bring it up to 815°C in 1 hour.
- Allow the ring to heat soak at this temperature for 2 hours. *(Error! Reference source not found. 74)*
- Wind the casting machine.
- Remove the crucible the oven with the casting tongs and place it in the bracket on the casting machine and place the metal ingots in the crucible.
- Use the gas-oxygen torch to melt the alloy. Adjust the flame and heat the alloy evenly by moving the torch around to cover all ingots.
- Cast immediately.

Accelerated casting method

Conventional casting techniques require 1-hour bench set for the investment and 1 to 2 hours for the wax elimination. Accelerated casting procedures have been proposed that reduce this time to 30 to 40 minutes.

The technique uses a phosphate-bonded investment that is given approximately 15 minutes bench set and 15-minute wax elimination by placing the ring in a furnace preheated to 815°C.
Recovery of the Casting

Gypsum-bonded investments quickly disintegrate, and elimination of residue is easily accomplished with a toothbrush. Final traces can be removed ultrasonically. Oxides are removed by pickling in 50% hydrochloric acid. Phosphate-bonded investments do not disintegrate and must be forcibly removed from the casting ring.

Evaluation

The casting is never fitted on the die until the inner surface has been carefully evaluated under magnification; even tiny imperfections can cause damage to the stone die.
Chapter 8
Finishing and Polishing of Fixed Restoration

Objectives

- Provide a description of finishing zones of a cast restoration.
- Describe the procedures of finishing each part of the cast restoration.
- Understand the importance of finishing of the cast restoration.

Zone 1: Internal margin

Objective:

To minimize any dissolution of the luting agent by a 1-mm-wide band of metal is closely adapted.

Procedure:

If a defect occurs in the marginal area, the restoration will have to be remade.

Small nodules, away enough from the margin, can be removed under a microscope using no. 1/4 round bur).

Zone 2: Internal Surface (Intaglio)

Objective:

No contact should exist between the die and the internal surface of the casting and a uniform space of 25 to 35 μm is necessary for the luting agent.

Any contact must be identified and relieved by selective grinding of the internal surface.

Procedure:

Marking agents can be used help in detecting any nodules in the internal surface. Nodules can be removed with a small round carbide bur under magnification. (Error! Reference source not found. 75)
Zone 3: The Sprue

Objective:
To reestablish proper occlusal morphology and function. The casting must be recontoured in the area of sprue attachment.

Procedure:
Section the sprue and reshape its area of attachment and refine the area with stones and disks. (Error! Reference source not found. 76)

Zone 4: proximal Contacts

Objective:
The proximal contact areas are adjusted so that they will be correct in the mouth.
Procedure:
placing a thin Mylar articulating film between adjacent castings or between the casting and the adjacent tooth is helpful. Selective adjustment is performed where markings results.

**Zone 5: Occlusal Surface**

**Objective:**
Occlusal morphology must ensure positional stability and satisfy all functional requirements.

**Procedure:**
Occlusal adjustments can be performed with flame-shaped finishing burs or diamonds. The correct technique for occlusal adjustment is to redevelop the anatomy of the entire ridge or cusp rather than grinding only the point of interference. Any nodules can be removed, and grooves can be defined with a finishing bur or small round bur. *(Error! Reference source not found. 77)*

![Fig. 77. Refining the occlusal anatomy.](image)

**Zone 6: Axial Walls**

**Objective:**
The axial wall should be smoothly contoured and highly polished.

**Procedure:**
Surface defects are removed by Grinding. The polishing is performed using a sequence of progressively finer abrasives.
Zone 7: External Margins

Objective:
To achieve a highly polished metal surface without ledges or steps as the transition is made from restoration to unprepared tooth.

Procedure:
Care must be taken not to remove more metal than is strictly necessary. Finishing is performed by gently brushing a fine-grit stone over the surface to remove casting roughness and followed by a soft rubber wheel or point and finally by rouge on a brush. (Error! Reference source not found. 78)

Fig. 78. Finishing of the external margin.
Chapter 9
Casting Defects

Objectives

- List different casting defects.
- Understand the cause of any of each casting defect.

No Casting

Cause:

- Sprue way obstruction due to presence of investment fragment or metallic sprue former was not removed.
- Molten alloy was not properly directed to the mold cavity.
- Premature solidification of the alloy.
- Fracture of investment at the base of ring.

Roughness

- Roughness may necessitate a remake if they were positioned near the margin or on the fitting surface.
- Generalized casting roughness may indicate a breakdown of the investment from excessive burnout temperature.

Cause:

- Rough surface of wax pattern
- Excessive use of wetting agent
- Overheating of investment
- Overheating of metal
- Increased W/P ratio of the investment mix.
Nodules

Bubbles of gas trapped between the wax pattern and the investment produce nodules on the casting surface. (Error! Reference source not found. 79)

When they are large or situated on a margin, they usually necessitate remaking of the restoration.

The key to avoiding nodules is a careful investing technique, a surfactant, vacuum spatulation, and careful coating of the wax pattern with investment.

Fins

Fins are caused by cracks in the investment. (Error! Reference source not found. 80)

Cause:

- weak mix of investment
- excessive casting force
- steam generated from too-rapid heating
- reheating an invested pattern
- improperly situated pattern
- rough handling of the ring after investing
Incomplete Casting

If an area of wax is too thin, an incomplete casting may result. *(Error! Reference source not found. 81)*

**Cause:**

- Inadequate heating of the metal
- Incomplete wax elimination
- Excessive cooling of the mold
- Insufficient casting force
- Not enough metal
- Metal spillage
Voids or Porosity

Cause:

- Voids in the casting may be caused by debris trapped in the mold (usually a particle of the investment undetected before wax elimination)
- Porosity resulting from solidification shrinkage ("suck back"). When a sprue is too narrow, too long, or incorrectly located or when a large casting is made in the absence of a chill vent. (Error! Reference source not found. 82)
- Gases may dissolve in the molten alloy during melting and leave porosity defects.
- Back pressure porosity may be caused by air pressure in the mold as the molten metal enters.

![Fig. 82. Suck-back porosity.](image)

Marginal Discrepancies

Cause:

- Distortion during removal of the wax pattern from the die
- Increased setting expansion following uneven expansion of the mold.
Dimensional Inaccuracies

The casting can be either too small or too large. Attention to detail is essential for an accurately expanded mold. A standardized procedure is needed in regards to liquid-powder ratio, spatulation, the ring liner, the amount of liquid added, and mold heating.
Objectives

- Describe the soldering gab.
- Understand the needs of soldering in construction of a fixed restoration.
- Identify the types of soldering techniques.
- Identify the difference between pre- and post-ceramic soldering.

Solder

Dental gold solders are given a fineness designation to indicate the proportion of pure gold contained in 1000 parts of alloy.

Modern casting alloys have become so complex that most manufacturers now recommend specifically formulated solders.

Solder can be classified as pre-solder or post-solder to indicate whether the solder is to be used for joining the components before or after porcelain application.

- Pre-ceramic solders are high-fusing alloys (fusing only slightly beneath the softening point of the parent alloy to be joined).
- Post-ceramic solders must flow well below the pyroplastic range of the porcelain.

Based on chemical composition, Solders must:

- Have the ability to resist tarnish and corrosion,
- Flow freely
- Match the color of the units that will be joined
- Be strong
**Soldering gab width**

As gap width increases, soldering accuracy decreases. Extremely small gap widths can prevent proper solder flow and lead to an incomplete or weak joint. An even soldering gap of about 0.25 mm is recommended. *(Error! Reference source not found. 83)*

![Fig. 83. Soldering gab.](image)

**Soldering Flux**

Flux is applied to a metal surface to remove oxides or prevent their formation.

Borax glass is used because of its affinity for copper oxides.

Fluxes are available in:

- Powder form
- Liquid form
- Paste form (popular because it can be easily placed and confined)

**Soldering Anti-flux**

Antiflux is placed on the casting before the flux application to limit the spreading of solder.

Types of anti-flux:

1. Graphite.

2. Iron oxide (rouge) in a suitable solvent such as turpentine.
Soldering Investment

Soldering investments are similar in composition to casting investments. Both gypsum and phosphate bonded, mixed with water only, have been used for soldering.

Several commercial soldering investments are available and should be used whenever possible.

Selection of soldering technique

Soldering index on the working cast or intra-orally to record the position of components is needed when fixed partial denture is assembled by soldering.

For all-metal fixed partial denture consisting of Type III or IV gold, soldering requires the use of a low-fusing solder (conventional soldering). A gas-air torch is used.

For fixed partial denture consisting of metal-ceramic units, the soldered connectors can be made be either:

- before the ceramic application with high-fusing solder
  it is called pre-ceramic application soldering or pre-soldering.
- or after the ceramic application with lower-fusing solder
  it is called post-soldering.

Soldering all-metal fixed partial denture: *(Error! Reference source not found. 84)*

Type III and IV gold retainers of fixed partial dentures are soldered with gold solder ranging from 615 to 650 fineness. An occlusal plaster index or autopolymerizing resin index is fabricated intraorally or in the dental laboratory.
Soldering metal-ceramic fixed partial dentures:

**Pre-ceramic Soldering** *(Error! Reference source not found. 85)*

- Advantages include allowing the connected prosthesis to be tried in the mouth in the unglazed state and any necessary adjustments can be made to the porcelain.
- A disadvantage results from having to apply the porcelain to a longer restoration, which needs support during firing to prevent high-temperature deformation or sag.

**Post-ceramic Soldering** *(Error! Reference source not found. 86)*

- The regular gold will melt if it is subjected to the high temperatures needed for porcelain application; therefore, all porcelain adjustment and firing, including that for the final staining and glazing, must be completed before the soldering. If further corrective adjustment is needed after soldering, the porcelain will have to be polished.
Heat Source

a) Torch soldering (gas-air torch)

b) Oven torch

   Furnace or oven soldering is performed under vacuum or in air. A piece of solder is placed at the joint space, and the casting and solder are heated simultaneously. (Error! Reference source not found. 87)

c) Infrared soldering

   A specially designed unit that uses an infrared light as its heat source. The connector area of the soldering assembly must be positioned precisely relative to the focal point of the reflector that concentrates the heat.

d) Laser welding

   Laser energy is extensively used for welding in many industries and has been described in dentistry.
It slowed higher strength and reduced corrosion in comparison to conventional soldering. *(Error! Reference source not found. 88)*

**Soldering technique**

- *Occlusal Soldering Index* can be done: intra-orally using plaster or ZOE to record impression of the occlusal surfaces of the fixed partial denture to capture the relative relationship of the individual components and transfer this to the laboratory. Also, can be done in the laboratory. *(Error! Reference source not found. 89)*

- *Investing*. seat each casting into the index and lute it to place with sticky wax. To protect regular gold margins from the soldering flame, they should be embedded in the investment. Box the assembly with a suitable sheet wax. Mix the investment carefully and flow it into the castings without trapping any air. Allow the invested block to bench set before removing the wax and preheating. *(Error! Reference source not found. 90)*
> **Wax Removal and Preheating.** Remove the plaster or ZOE index after the investment has fully set. The joint space must be free of investment. Flowing a little flux into the joint space while the soldering block is still warm from wax removal. Preheat the investment in a burnout furnace to 650°C (for low-heat soldering) or 850°C (for preceramic soldering).

> **Torch Soldering (Low Heat).** Transfer the assembly to a soldering stand with a Bunsen flame underneath and place a piece of solder above the gap. Adjust the gas-air torch to give a sharp blue cone. The reducing zone of the flame is used to heat the investment block. Heat evenly and slowly, moving the tip of the flame constantly. This is important in post-ceramic application soldering because the porcelain may easily crack. When the metal glows brightly, the solder will melt and flow into the joint space. *(Error! Reference source not found. 91)*

---

![Investing](image)

**Fig. 90. Investing.**

![Solder flow and spin](image)

**Fig. 91. The solder flow and spin in the connector area.**
- **Torch Soldering (High Heat).** Gas-oxygen torches for high-heat pre-ceramic soldering and use a miniature needle tip so that the flame can be pinpointed on the joint space. Place the solder above the gap and concentrate the reducing zone of the flame on the joint space. When the solder melts, draw it into the joint and quickly "chase" it around with the flame. (*Error! Reference source not found. 92*)

Fig. 92. Concentrate the flame on the joint area.
Chapter 11
Fabrication of Provisional Restoration

Objectives

- Understand the importance of provisional restoration.
- Identify the types of provision restoration.
- Describe the techniques of fabricating a provisional restoration.

Types of provisional restorations

Prefabricated: it is used only for single crown. It includes stock aluminum cylinders, metal crowns, celluloid shells and polycarbonate shells.

Custom-made: it is fabricated from several resin materials and by direct or indirect technique.

Techniques for custom provisional restorations

There are a variety of techniques for making a mold to form the outer surface of a custom provisional restoration. The inner surfaces will be shaped by a cast of the preparation.

Both elastomeric and alginate overimpressions made on the diagnostic cast, or in the mouth, before the tooth preparation.

A template formed from clear thermoplastic resin also can be used. It is shaped on a diagnostic cast, using a vacuum forming machine. The template is filled with resin and applied to the prepared teeth or to a fast-setting plaster cast of the prepared teeth.
Overimpression-fabricated provisional crown

- The overimpression can be made in the patient's or from the diagnostic cast. The diagnostic cast is immersed in water for 5 minutes. When it has set, the overimpression is removed from the diagnostic cast. The impression is wrapped in a wet paper towel for later use. *(Error! Reference source not found. 93)*

![Fig. 93. Impression is made from diagnostic cast.](image)

- After tooth preparation, another impression is made. It is poured up with a quick-setting plaster. The cast is trimmed on a model trimmer. *(Error! Reference source not found. 94)*

![Fig. 94. Trimmed plaster cast.](image)

- Coat the prepared tooth and adjacent areas of the cast with a separating medium. Allow the material to dry before mixing the acrylic resin.

- Mix tooth-colored acrylic resin according to manufacturers' instructions. Place the resin in the overimpression so that it completely fills the crown area of the tooth for which the provisional restoration is being made. *(Error! Reference source not found. 95)*
Seat the cast into the overimpression. The force used to seat the cast into the alginate impression is critical. (Error! Reference source not found. 96)

Place the overimpression-plaster cast assembly in hot tap water for 5 minutes or into a pressure pot.

Trim the excess resin from the provisional restoration. Smooth the axial surfaces near the margins of the restoration.

Template-fabricated provisional fixed partial denture

Place a denture tooth in the edentulous space on the diagnostic cast. (Error! Reference source not found. 97)
Place a sheet of 0.020-inch-thick resin in the frame of the vacuum forming machine with the shiny surface down. Turn on the heating element of the machine and swing it into position over the plastic sheet. The resin sheet is heated and vacuum is on. Grasping the handles on the frame that holds the heated coping material, forcefully lower the frame over the perforated stage. *(Error! Reference source not found. 98)*

Trim the template with a pair of scissors. It should extend at least one tooth on either side of the prepared teeth.

After teeth preparation, make an alginate impression of them and pour it in fast-setting plaster. The plaster cast will include replicas of soft tissue and teeth that are not needed. Try on the template to verify its fit.
Coat the cast with separating medium and allow it to dry. Mix the acrylic resin and place some on protected areas of the cast, such as interproximal spaces and in grooves and boxes. Fill the area for which the provisional fixed partial denture is being made. Place some extra bulk in the portion that will serve as the pontic.

Wrap rubber bands around the template and cast. Place the cast in a pressure pot or warm water for about 5 minutes.

Remove the fixed partial denture from the cast. The pontic should be trimmed. The pontic should have the same general shape that the pontic on the permanent prosthesis will have.
Chapter 12
Porcelain Fused to Metal Restorations

Objectives
- Describe the components of metal ceramic restorations.
- Provide a description of framework designed for metal ceramic restoration.
- List the requirements for metal and porcelain for metal ceramic restoration.
- Understand the nature of metal ceramic bonding.

Requirements of alloy used for metal-ceramic restorations

1. The coefficient of thermal expansion of porcelain and metal should be compatible. The optimal difference between the two would be no greater than $1 \times 10^{-6} \degree C$.

2. The melting range temperature of the metal should be higher than the fusion temperature of porcelain by at least 170-280 °C.

3. The metal should be rigid enough. It should not flex during seating or when subjected to occlusal forces.

Alloy used for metal-ceramic restorations

Alloys used for metal-ceramic restorations are classified by ADA according to their noble metal content into:

a. High noble metal alloys

They contain a minimum of 60 % by weight of noble element and at least 40 % gold.
Three systems exist in this class:

- Gold-platinum-palladium
- Gold-palladium-silver
- Gold-palladium

b. Noble metal alloys

They contain a minimum of 25% by weight of noble metal with no gold percentage requirement.

There are three types of alloy systems in this class:

- Palladium-silver
- Palladium-cupper-gallium
- Palladium-gallium

c. Base metal alloys

These alloys were introduced in the early 1970s having less than 25% by weight noble metal and with no requirement for gold. By 1981, the percentage of their use increased up to 70% due to unstable price of noble metals.

They include:

- Nickel-chromium
- Cobalt-chromium
- Titanium alloys
Basic principles design of metal substructure design

There are several principles to be adopted in metal design for metal-ceramic restorations, which are:

[1] No sharp or acute angles.

Fig. 99. No sharp or acute angles.

Sharp angles on the veneering surface should be avoided as it leads to initiations of internal stress in the overlying porcelain. (Error! Reference source not found. 99)


Fig. 100. Metal should provide proper support.

Lack of metal support results in porcelain fracture due to brittleness and low flexural strength of porcelain material which gain its support from underlying metal. (Error! Reference source not found. 100)

Contact at porcelain/metal junction should be avoided as it leads to porcelain fracture. The metal-ceramic interface must be at least 1.5 mm away from all centric occlusal contacts to avoid metal flow and subsequent ceramic fracture.

[4] The junction between metal and ceramic should be distinct.

The junction should be as definite (90-degree angle) and as smooth as possible to make finishing easier during all fabrication stages. (Error! Reference source not found. 101)


The metal substructure should be designed to allow porcelain to wrap the metal. (Error! Reference source not found. 102)

Any deficiencies in the incisal edge, buccal or lingual cusps should be compensated for with extra-metal thickness.

[7] Metal thickness should provide adequate rigidity.

The metal framework should be of sufficient thickness to prevent its distortion during porcelain firing or flexing during its seating on prepared tooth or under occlusal load.

A minimum thickness for noble metal alloy is 0.3-0.5 mm and 0.2-0.3 mm is for base metal alloys.


Occlusal contacts: it can be located on either metal or porcelain. Whenever possible, contacts should be located on metals. Contact should be away from porcelain-metal junction (1-1.5 mm) at the position of maximum intercuspation to avoid porcelain fracture.

anterior restoration: it must not be placed too close to the incisal edge because this can cause. The contacts can be placed entirely on porcelain when there is inadequate vertical overlap to place the contact on metal.

[9] Facial Margins

The conventional facial margin for a metal-ceramic crown was a narrow metal collar. To avoid an un-esthetic display of metal on highly visible teeth, the facial finish line was placed sub-gingivally, which may contribute to chronic gingival inflammation.

To avoid showing an unsightly band of metal, porcelain was extended onto the collar itself. This can create an over-contoured gingival margin; thin, fracture-prone porcelain or an undetected open margin.

Frustration with the esthetics of the conventional metal collar led to the use of the all-porcelain facial margin.
Porcelain-metal bonding

Porcelain-metal bonding Mechanism

van der Waal’s forces

These are forces caused by molecular attraction between two charged atoms as they approach each other within a range where no actual exchange of electrons occurs. (Error! Reference source not found. 103)

Mechanical retention

Mechanical bonding is achieved by grinding the metal surfaces using abrasives and/or sandblasting using aluminum oxide particles with different grits followed by steam cleaning. It increases the metal surface roughness by creating may irregularities into which the opaque porcelain can flow during firing resulting in micro-mechanical interlocking.

Compression bonding

Ideally, the coefficient of thermal expansion of metal and ceramic must closely match to achieve a strong interfacial bond. Typically, the coefficient of thermal expansion value for metal range from 13.5-14.5 x 10^-6/°C and that for ceramic ranges from 13-14 x 10^-6/°C.

By cooling, the metal will try to contract more than the ceramic owing to its higher coefficient of expansion. This leaves the ceramics in a state of compressive stresses at room temperature which is beneficial. (Error! Reference source not found. 104)
Chemical bonding

It is the most significant mechanism of porcelain-metal attachment.

**Sandwich theory:** the oxide layer is permanently bonded to the metal substructure on one side with the dental porcelain on the other side. *(Error! Reference source not found. 105)*

**Oxide dissolution theory:** The oxide layer is completely dissolved in the molten glass of the opaque porcelain layer and the porcelain is brought into atomic contact with the metal surface for direct chemical bonding.

Elements needed for chemical bonding: tin, iron, indium for high noble alloys.

Tin and indium, Co, Cu, Ga for noble alloys. As direct oxidation of the constituents of the base metal alloys e.g., nickel, cobalt and chromium.
Requirements for porcelain used with metal-ceramic restorations

1. Should have low fusion temperatures being about 170-280 °C less than the melting range of the cast metal alloys.

2. Should have a coefficient of thermal expansion slightly lower than that of metal substructure by 0.5-1.0 x 10^{-6}/°C to enhance bond strength and avoid crack formation.

3. Should be of high viscosity.

4. Should resist vitrification.

5. Should be chemically and optically stable.

6. Should be able to withstand oral environment.

7. Should not abrade opposing teeth.

Porcelain build-up (Error! Reference source not found. 106)

Instruments and equipment:

- Brushes
- Carving instruments
- Razor knifes

Fig. 106. Recommended minimal thickness of metal-ceramic layers.
- Spatulas
- Hemostats
- Condensation mallets
- It can be used to condense the porcelain buildup.

**Porcelain furnaces**

The porcelain furnace can be classified also according to the manner of entry into the muffle:

- Front-loading furnace
- Vertical-loading furnace
- Vertical muffle with clam shell design

**Porcelain condensation:**

At least five different methods of porcelain condensation are recognized:

- Capillary action with blotting
- Vibration
- Spatulation
- Whipping
- Dry powder addition

*The opaque porcelain* (Error! Reference source not found. 107)

**Function:**

1. It establishes the porcelain-to-metal bond.
2. It masks the color of the metal substructure.
3. It initiates the development of the selected shade of dental porcelain.

**Thickness:** is bout 0.2-0.3 mm.
Application of opaque porcelain:

- Glass rod technique
- Brush technique
- Spray technique

Body porcelain refers to four types of porcelain powder used to create the restoration:

- Dentin porcelain
- Enamel porcelain
- Translucent porcelain
- Body modifiers
Bisque stages of porcelain maturation

Three bisque stages are recognized:

- **Low-bisque**
  This is the least mature stage of development of the ceramic characterized by a structure in which the grains of porcelain have just begun to soften and fuse at their contact angles.

- **Medium-bisque**
  This is the next level of maturation; the porcelain grains have fused together more substantially. Less porosity is present and it is evident that some shrinkage has occurred.

- **High-bisque**
  A high-bisque back is the desired stage of porcelain maturation. The grains have fused together and the maximum amount of air has been eliminated for the level of condensation performed and the amount of vacuum used.

**Glazing** *(Error! Reference source not found. 109)*

Glaze fills small surface porosity and irregularities and when fired, helps to re-create the external sheen or glossy appearance of a natural tooth.

- **Auto-glazing (self-glazing) (natural glaze) technique**
- **Add-on glazing (over-glazing) techniques**
  A slurry material (glaze material) is applied to the porcelain surface.

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Fig. 109. Metal-ceramic restorations after Glazing.
Chapter 13
Introduction to All Ceramic Restorations

Objectives
- List the advantages and disadvantages of all ceramic restorations.
- Understand the limitations of using ceramic restorations.
- Identify computer controlled manufacturing of all ceramic restorations.

Definition
Dental ceramics are nonmetallic, inorganic structures, contains compounds of oxygen with one or more metallic or semi-metallic elements.

The word ceramics is derived from keramikos. This is the ancient Greek word for “earthen”. While, the word porcelain is derived from porcellana which is the Italian name for a small seashell.

Advantages of all ceramic restorations
Dental ceramics are attractive because of their:

1. Biocompatibility.
2. Optimum esthetics
3. Long-term color stability
4. Wear resistance
5. Ability to be formed into precise shapes
6. A coefficient of thermal expansion similar to that of dentin
7. Densely sintered aluminum oxide and feldspathic porcelain have a radiographic contrast similar to that of dentin
Disadvantages of all ceramic restorations

1. Ceramic materials are brittle, limited in their tensile strength and subject to time-dependent stress failure which in most cases, limits their use to anterior teeth.

2. Marginal adaptation is a matter of concern

3. Almost all-ceramic crowns have inferior marginal adaptation as compared to metal-ceramic crowns.

4. All-ceramic crowns require more tooth reduction and are less conservative than metal-ceramic crowns.

5. All types of porcelains will cause accelerated attrition of the opposing dentition when in gliding contact with natural teeth.

Classification of ceramic restorations

According to composition, ceramic restoration can be classified into:

1. Silicate ceramics
2. Oxide ceramics
3. Non-oxide ceramics

Silicate ceramics

Characteristic: the presence of quartz, feldspate and kaolin. The basic component being silica dioxide. These are heterogeneous materials composed of crystals surrounded by a vitreous phase.

Based on their composition, silicate porcelains can be classified as feldspates or alumina porcelains.

[1] Feldspates

The predominant element is silica oxide or quartz in a proportion of 46-66% versus 11-17% of alumina.
The feldspate porcelains in turn are subclassified as follows:

a) Conventional feldspate porcelains.

These offer very good esthetic effects but the main problem is that they are fragile (low fracture resistance: 56.5 MPa).
Ex:
- d-SING
- Luxor
- Flexoceram
- IPS Classic
- Empress esthetic

b) High resistance feldspate porcelains

In this case we have the following materials:

**Feldspate porcelain reinforced with leucite crystals**

The chemical composition comprises quartz (68%) and aluminum oxide (18%). As a result of the pressing process used to manufacture these materials, porosity is reduced and adequate and reproducible fit precision is achieved.

The perfect distribution of the leucite crystals within the glass matrix, observable during the cooling phase and after pressing, contributes to increase resistance without significantly diminishing translucency.

Strength: 160-300 MPa.

Examples of this type of porcelain include:
- IPS-Empress 1
- Optec HSP
- Mirage
- Finesse

**(b) Feldspate porcelain reinforced with lithium oxide**

The chemical composition comprises quartz (57-80%), lithium oxide (11-19%) and aluminum oxide (0-5%).

The incorporation of these crystalline particles increases the flexion resistance to 320-450 MPa.
Examples include:
* IPS Empress II

2- Alumina porcelains

These porcelains contain an increased proportion of alumina (40-85%), while the silica oxide concentration is reduced from 60% to 15%.

This group is the same as the Conventional alumina porcelains.

The proportion of aluminum oxide in this case does not exceed 50%.

These materials are indicated for the preparation of complete crowns and for porcelain coating with aluminum oxide and metal - though facets (veneers) can also be manufactured.

- Examples of this type of porcelain include:
  * Vitadur N
  * Vitadur Alpha

Oxide ceramics

The oxide ceramics comprise both simple oxides such as aluminum oxide, zirconium dioxide and titanium dioxide, as well as complex oxides such as spinell, ferrite, etc.

It contains a principle crystalline phase (e.g., Al2O3, MgO, ZrO2 or ThO2) with either no glass phase or a small content of glass phase.

Oxide ceramics contain only oxidant components, though the same term is commonly used in reference to ceramics with blended oxide components. These are polycrystalline materials with little or no vitreous phase (representing the weak point of porcelain).

Due to their great opacity, they are used as internal copings in ceramic restorations.
[1] Aluminum oxide ceramics

It is multi-component or mixed oxide structure

Examples of this type of porcelain include:

a) In-Ceram Alumina
   This high alumina content affords a resistance to flexion of 400-600 MPa.

b) In-Ceram Spinell
   Where the substitution of alumina with mixed magnesium and aluminum oxide affords increased porcelain coping translucency.

c) In-Ceram Zirconium
   Comprising 67% aluminum oxide and 33% zirconium oxide and yielding a resistance to flexion of up to 600-800 MPa.

d) Procera All-Ceram
   This material contains 99.9% aluminum oxides, with a fracture resistance of 680 MPa, and is in turn coated with conventional alumina ceramic.

[2] Zirconium oxide ceramics

Zirconium oxide is a polycrystalline material with a tetragonal structure partially stabilized with yttrium oxide

The internal copings are formed by a mass of compacted and practically fused crystals, thus giving rise to a near absence of porosities thanks to the core processing applied in the dental laboratory, based on CAD-CAM techniques.

Machinable ceramics

The two principle machining approaches for dental restorations are:

(1) copy milling

(2) CAD/CAM milling
   Computer-aided design / computer-aided manufacturing (CAD/CAM) technology was introduced to the dental community in the early 1980s.
Definition: the three-dimensional planning of a workpiece on the screen of a computer with subsequent automated production by a computer controlled machine tool.

CAD/CAM systems have three components:

- **Data capture or scanning** to capture and record data about the oral environment (tooth preparation, adjacent teeth and occluding tooth geometry)
- **CAD** to design the restoration to fit the preparation and to perform according to conventional dental requirements.
- **CAM** to fabricate the restoration

CAM Technology:

- Subtractive technique from a solid block
- Additive technique by applying material on a die
- Solid free form fabrication

Business models for producing CAD/CAM restorations

As might be expected, based on the number of CAD/CAM systems available and the broad range in size and cost, different business models for producing CAD/CAM restorations have emerged:

- in-office systems.
- dental laboratory systems.
- dental laboratories working in collaboration with a production center.
References:


- Book Coordinator; Mostafa Fathallah
- General Directorate of Technical Education for Health