Dental implants

Dental implant: a surgical component (anchor) implanted into the oral tissues beneath the mucosa &/or the periosteal layer or within the bone to provide permanent support for a fixed or removable dental prosthesis. It is made of *alloplastic material & is regarded as biocompatible, biofunctional & **permucosal device.

* Inorganic or non-biologic material implanted into living organic tissue e.g metal, ceramic, or polymeric materials.

** The function of which is to prevent bacteria and inflammatory agents from entering the tissues by having good seal.

Types of dental implants:

1. Transdental implant (endodontic implant): a smooth and /or threaded pin implant that extends through the root canal of a tooth into periapical bone and inserted into a previously prepared channel in the bone above the root. It is used to stabilize a mobile tooth, sometimes called an endodontic stabilizer. It is regarded as a metallic extension of the root with the purpose of increasing the root-to-crown ratio to give the tooth better stability in the arch. Therefore, they serve another purpose other than the replacement of lost tooth which is the stabilization and preservation of remaining natural tooth (Figure 1A).

2. Transosteal implants: a dental implant composed of a metal plate with retentive pins that hold it against the inferior border of the mandible and of two transosteal pins that penetrate through the full thickness of the mandible and pass into the mouth. The two pins that will eventually protrude through the gums can be used to attach to an overdenture-type prosthesis. It is also called mandibular staple implant or transmandibuler implant (Figure 1B).

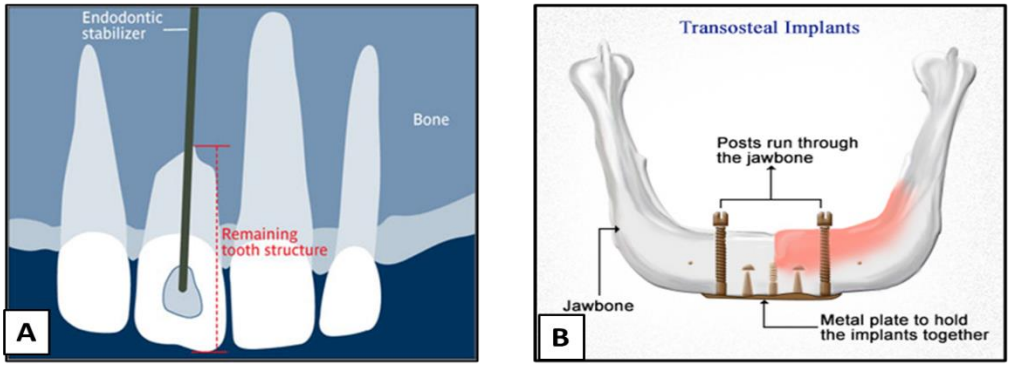

Figure 1: A) Transdental implant, B) Transosteal implant.

3. Subperiostal implants: dental implant that is placed beneath the periosteum while overlying the bony cortex (Figure 2A). It is composed of:

- Subperiosteal dental implant substructure: a cast metal framework that fits on the residual ridge beneath the periosteum and provides support for the dental prosthesis by means of posts or other mechanisms protruding through the mucosa.
- Subperiosteal dental implant abutment: that portion of the implant that protrudes through the mucosa into the oral cavity for retention or support of a crown, fixed or removable prosthesis.
- Subperiosteal dental implant superstructure: the metal framework, usually placed within a removable dental prosthesis that fits onto the dental implant abutments(s) and provides retention for artificial teeth and the denture material of the prosthesis.

4. Endosteal dental implant: it is a dental implant that extends & embedded into the basal bone for supporting a dental prosthesis (Figure 2B). It can be classified into:

- **Root form implant**: it is used where there is adequate amount of bone. It is available in many forms (cylinder, screw & a combination root form). Its smooth surface is usually coated with hydroxyaptite or plasma spray. While self-tapping forms are usually threaded implants.
- **Blade form implant**: it may be either prefabricated or custom made. It is indicated when the width of the bone is not adequate for placement of the root form. It is indicated as well in full arch edentulous reconstruction.

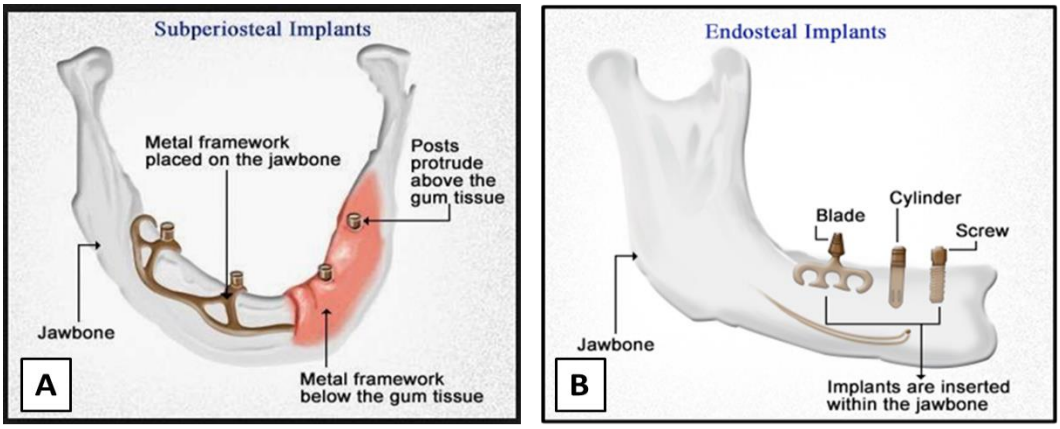

Figure 2: A) Subperiostal implants, B) Endosteal dental implant.

Osseointegration: a direct structural and functional contact between a living bone and the surface of a load-carrying implant without intervening connective tissue. Dental implant can provide a foundation to support a prosthesis & can transmit the occlusal forces directly to the bone.

Factors determining the success of osseointegrated implants:

1-Implants biocompatibility: is the compatibility of any foreign material with a living organism. Biocompatible means capable of existing in harmony with the surrounding biologic environment. There must be various degree of biocompatibility. Materials used for the fabrication of dental implants can be categorized according to their chemical composition or the biological responses they elicit when implanted. Based on the ability of the implant to stimulate bone formation, implants can be classified into:

- **Bio-tolerant materials**: these materials are characterized by a low grade of tissue reaction, and often fibrous tissue can be histologically identified between the bone and the fixture. Materials included in this category are stainless steel, chrome cobalt alloy and gold alloy.
- **Bio-inert materials:** these materials are characterized by direct contact with the bone, with little or no apparent reaction within the host tissue. Materials included in this group are titanium, aluminum oxide and various ceramic materials.
- **Bio-active materials:** these materials promote osteogenic activity within the host tissue and bond chemically to bone calcium phosphate apatite. Bioceramic & bioglass are Bio-active materials**.**
- **Bio-inert and structure osteotropic materials:** titanium with rough surfaces is an example of such material forming physical and chemical bonds to the bone.

2- Implant materials: The physical and chemical properties of implant materials influence the prognosis of implant therapy. These properties include the microstructure of the implant, its surface composition & characteristics, as well as design factors. An ideal implant material should be biocompatible, with adequate toughness, strength, corrosion, wear and fracture resistance. From a chemical point of view, dental implants may be made from:

i. **Metals:** The favorable long-term clinical survival rates reported for titanium have made it the "gold standard" material for the fabrication of endosseous dental implants. There are four grades of commercially pure titanium (CpTi) and two titanium (Ti) alloys.
   Commercially pure titanium oxidizes in atmosphere to titanium oxide layer which adhere firmly to bone. It may be sprayed with titanium plasma to increase roughness & the surface area of the implant surface for better fixation to bone. CpTi contains some trace elements of carbon, oxygen, nitrogen and iron which markedly improve its mechanical properties.
   Titanium-6Aluminium-4Vanadium [Ti-6AI-4V] alloy is titanium alloy containing 6% aluminium and 4% vanadium. Heat treatment of this alloy & the presence of aluminum increase the strength of the alloy, resulting in favourable mechanical and physical properties that make them excellent implant materials. However, bone usually shows stronger reaction to CpTi than to Ti-6AI-4V.
   Occasionally, various metals and metal alloys involving gold, stainless steel and cobalt chromium have been used. However, adverse tissue reactions and a low success rate weakened their long-term clinical application and made these materials outdated within the oral implant industry.

ii. **Ceramics** (e.g. alumina, carbon, zirconia, bioactive glasses, and calcium phosphate materials).
   Hydroxyapatite (HA) is one of calcium phosphate ceramic materials that was tried as a solid material for use as oral implant, but due to its brittle nature, fracture occur too often. Because HA stimulated rapid bone response, so it used as a coating to the dental implants to enhance the osseointegration. Also, HA can be used for augmentation in bone defects.
   Zirconia holds a unique place amongst oxide ceramics due to its excellent mechanical properties, superior corrosion and wear resistance, as well as a high flexural strength compared to other dental ceramics.

iii. **Polymers** (e.g. Polymethylmethacrylate, Polyethylene): polymers were biologically tolerable substances. Polymers do not generate electrolytic current as do metals & they are more esthetically pleasing. However, they have inferior mechanical properties with lack of adhesion to living tissues and have adverse immunologic reactions.

3-Implant design; most common design for osseointegration is the cylindrical design. They can be either threaded, HA coated or not. Unsuitable implant designs may lead to relative lack of implant stability resulting in implant micro movements and subsequent implant loss.

4-Implant surface: smooth implant surface is less prone for osseointegration as compared to an implant with mild surface roughness which can produce the best bone fixation. Too smooth implant surface will result in primary failure in osseointegration. In addition, if the implant surface was too rough, there will be a risk of adverse bone reaction and secondary loss of integration.

5-Implant bed: a healthy site is required for good osseointegration. Old age does not cause poorer implant result. While previously irradiated area is contraindicated. A one-year delay after irradiation before inserting the implant is recommended. The expected success results are about 10% lower than for non-irradiated patients. Smoking is contraindicated for implant placement as it affects the vascular supply to the surgical site due to vasoconstriction so it will impair soft tissue wound healing. Also, it affects the immune system of the patient and impair normal cellular function and has negative effect on the bone, so the implant failure is about twice that of the non- smoker patients.

6-Surgical technique: the surgical site should be subjected to minimum possible trauma. A continuous careful cooling is arranged while the surgical drilling is performed. Sharp instruments should be used at a low rotatory rate & graded series of drills.

7-Loading conditions: overloading the premature healing bone tissue will cause failure of osseoitegration. A two-stage implant insertion is advised. The implant is first inserted in the bone and then the soft tissue is sutured back so that the implant will be incorporated in bone under protected conditions. Second surgery is carried out 3-6 month later

when osseoitegration is complete. The buried implant is exposed and connected to the oral cavity by means of abutment.

8-Infection control: infection especially from periodontium should be avoided. All surgical protocols to avoid infection should be followed.

Advantages of Dental Implants:

1- Bone preservation: when a tooth is extracted, the body senses the loss and begins to resorb the bone that used to support that tooth. In the case of multiple missing teeth, this can lead to facial collapse, inability to wear even removable prosthesis. This is in addition to the esthetic problems. Therefore, the presence of a dental implant signals to the body that this bone is still needed, the implant stimulates the bone like a natural tooth and these difficulties are prevented.

2- Improve function: implants can be designed such that the effect of harmful forces on the residual ridge can be minimized. In addition, it was found that the chewing efficiency of the dental implant is greater than other prosthetic replacements.

3- Aesthetic: the dental implant provides a natural appearance of the tooth as it emerges directly from the soft tissue.

4- Stability and retention: endosseous implants are more stable and retentive than other retentive elements due to ossintegration process.

5- Comfort: implants are more comfortable as the extent of the flanges of the final prosthesis can be reduced.

Indications of Dental Implants:

1- They are used as alternative to complete dentures when we have completely edentulous patient who is unable to tolerate a conventional prosthesis for any reason (poor stability & retention, nausea & gaging reflex, or psychological reasons).

2- They are used as alternative to fixed prosthesis when there is a single missing tooth with adjacent sound teeth & reduction of these teeth structure is needed for abutment preparation.

3- They are used as alternative to partial dentures as the implant treatment may be considered a preferred option when the patient refuses to use removable type prosthesis and in difficult prosthetic situation (e.g. distal extension saddle, extensive saddles where support for partial denture or bridge is limited & anterior saddle cases).

4- They are to retain maxillofacial prosthesis (ears, eyes, obturators).

Contraindications of Dental Implants:

1- Patient whose systemic health preclude minor oral surgery procedure (unregulated diabetic, coagulation problems, periodic use of steroids).
2- Patients with poor oral hygiene.
3- High-dose irradiated patients.
4- Patients with history of psychotic disorder.
5- Pathology of hard or soft tissue.
6- Heavy smoker patients.
7- Young patients under the age of 18 years old because the bone is not completely formed. Extreme young age is a relative contraindication to the insertion of the implants. The general recommendation is to wait completion of growth before inserting oral implants in young individuals.

Mechanical structure of the implant (Figure 3)

1- Implant body or fixture: that part that is placed within the bone during first stage of surgery. It could be threaded or non-threaded. The threaded implant bodies are available in commercially pure titanium or as titanium alloys with or without hydroxyapatite coating.

2- Cover or healing screw: during the healing phase, the screw is normally placed in the superior surface of the body. Its function is to facilitate the suturing of soft tissue & to prevent the growth of the tissue over the edge of the implant.

3- Healing abutment: they are dome shaped screws placed over the healing screw after the second stage of the surgery and before the insertion of the prosthesis. They may range in length from 2 to 10 mm. They project through the soft tissue into the oral cavity. Their function is to prevent overgrowth of tissues around the implants during the healing phase.

4- Impression or transfer posts: it is a small stem facilitates the transfer of intraoral location of the implant or abutment to similar position on the cast. They are placed over the implant body during impression making.

5- Laboratory analogues: these are machined structures which represent the body of the implant. They are placed on the laboratory cast to fabricate an implant supported prosthesis.

6- Abutment: is the part of the implant which resemble a prepared tooth and is designed to be screwed into the implant body. It is the primary component, which provides retention to the prosthesis.

7-Prosthesis retaining screw: it penetrates the fixed restoration and secure it to the abutment.

Figure 3: Mechanical structure of the implant. 1) Implant body or fixture, 2) cover screw, 3) healing abutment, 4) Impression posts, 5) Laboratory analogue, 6) Abutment, 7) Prosthesis retaining screw.

Diagnosis and assessment of dental implant sites:

1. Medical history: Several conditions could complicate the implant therapy & the healing process (e.g. Bleeding disorders, Paget's disease, radiation therapy, uncontrolled diabetes, epilepsy, steroid therapy, hyperthyroidism and tobacco and alcohol abuse).

2. Dental history: for soft tissue condition, health of periodontium, remaining teeth condition, the dentulous area, the present occlusion and associated muscle tenderness, limited range of mandibular motion, TMJ disorders and habits like bruxism.

3. Oral Examination: of pre-existing periodontal disease and caries which should be controlled. The bony implant site must be of a good quality and to have bone of enough height & width for implant placement. There should be enough inter-ridge space (minimum of 7 mm) for both implant superstructure and the prosthesis. There should be enough space for implant placement between the existing teeth (minimum 7mm).

4. Radiographic examination for collecting information like periapical radiographs for amount and quality of the bone. Cephalometric radiograph for labiolingual dimensions and the loss of the vertical dimension (Figure 4A). Panoramic radiograph to evaluate the vertical height of the bone, location and extent of the limiting

anatomical structure, the possible pathological findings and bone quality or density (Figure 4B). Computed tomography for the cross-sectional anatomy of the alveolar ridges especially for maxillary arch (Fig 4C).

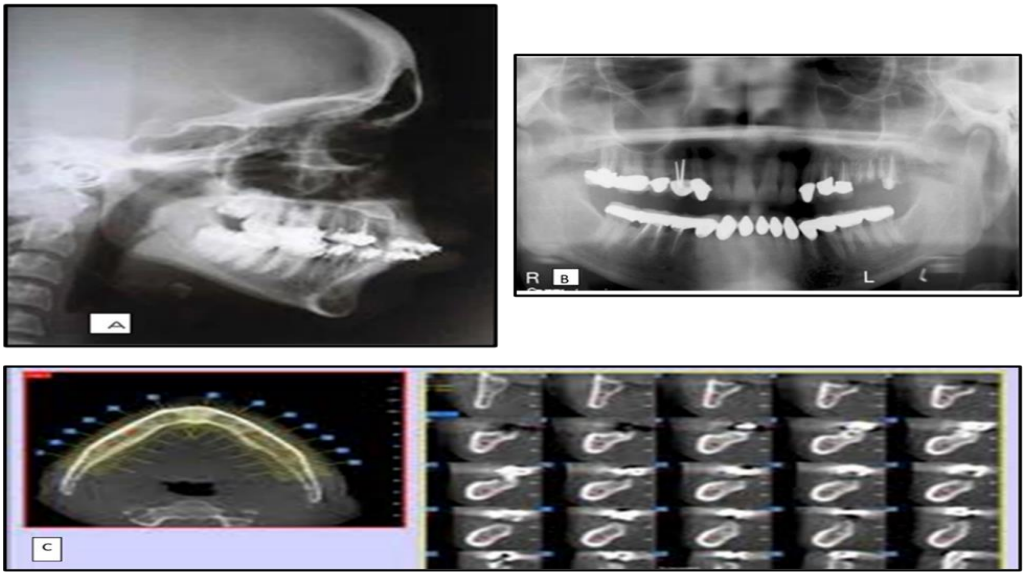

Figure 4: A. Cephalometric radiograph, B. Panoramic, C. Computed tomography

Treatment Planning: It needs a teamwork between oral surgeon, prosthodontist & dental technician. Based on the gathered data & clinical examination, a detailed treatment plan can be proposed including locations and directions for fixture and anatomical limits for fixture placement (e.g. nasal cavity, maxillary sinuses & inferior alveolar canal).

Treatment options for completely edentulous jaws are:

A. Implant -Supported Fixed Prothesis

1. Fixed prosthesis with 4-6 implants can generate occlusal forces approximately that of natural teeth while conventional dentures generate 1/4 the force of natural dentition.
2. Clinical successes suggested about 5 implants placed to support a 10 to 12-unit fixed mandibular prosthesis and 8 to 10-unit maxillary prosthesis (Fig 5).
3. The younger the edentulous patient, the greater the benefit from implant-supported fixed prosthesis.

Figure 5: Implant -Supported Fixed Prothesis

B. Implant- Supported Removable dentures

1. Maxillary removable denture requires the placement of a minimum of 3-4 implants of 10 mm or longer. More implants should be placed when reduced host bone site prevents the placement of 10 mm fixture.
2. For mandibular denture, two implant appears to be adequate. The implants are placed between the mental foramina with around 22 to 27 mm space between them.
3. Ball or magnetic attachments offer an easy way to retain implant overdentures and are recommended when implants are placed underneath a used complete denture so that the denture does not have to be remade (Fig 6A, B).
4. Bar attachments are recommended for upper overdentures, resorbed lower residual ridges (Fig 6C, D), and mandibles with more than two implants due to pronounced ridge curvature (Fig 6E, F). The bars can be soldered or casted in the lab.
5. When the anterior residual ridge is only slightly curved, the connecting bar should splint two implants to allow for rotation of the prosthesis around the inter-implant axis. While, curved residual ridge usually necessitates placement of three or more implants with an inter-implant distance preferably exceeding 10 to 12 mm, to prevent the splinting bar's encroachment on tongue space.

Advantages of implant-supported removable prosthesis over a fixed-implant supported restoration in completely edentulous patient:

1. Facial esthetics can be enhanced when labial flanges of the removable restoration replace lost bone width and height and support the labial soft tissues.

2. The prosthesis can be removed at night to manage night parafunction (bruxism).
3. Fewer implants may be required.
4. Less bone augmentation may be required before implant insertion.
5. The treatment may be less expensive for the patient.
6. Daily home care & hygiene maintenance is easier.

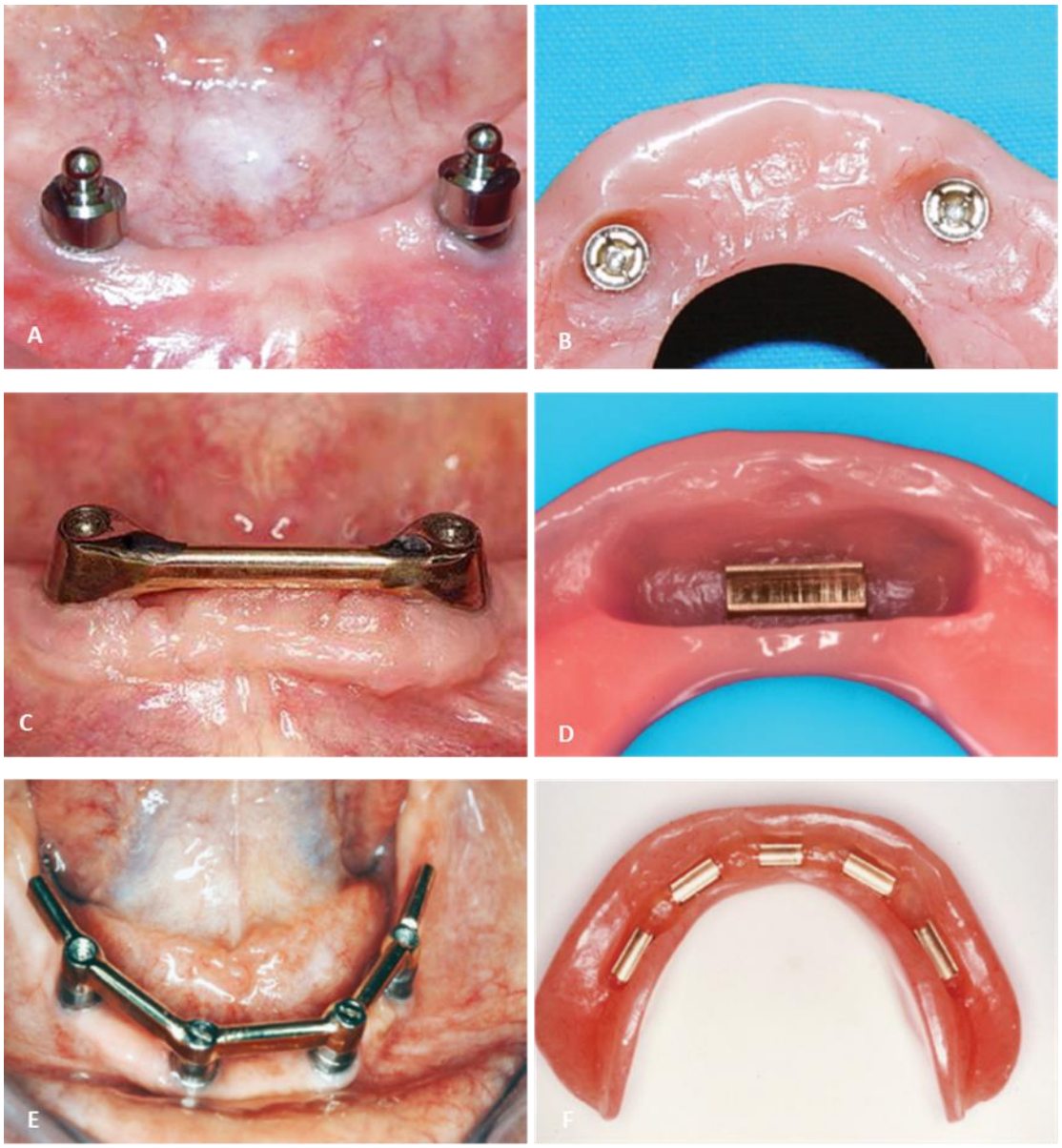

Figure 6: A. Two implants with ball attachments support mandibular overdenture, B. Complete overdenture with socket superstructure to fit ball attachments of underneath implants, C. Connecting bar splints two implants, D. Complete overdenture with clip superstructure to fit the bar attachment of the underneath implants, E. Connecting bars splint four implants used in curved residual ridge, F. Complete overdenture with clips superstructure to fit the bar attachments of the underneath implants.

Prosthesis fabrication

At the time of insertion of implant body (stage I surgery), a cover healing screw is placed into the top of the implant to prevent bone, soft tissue or debris from invading the abutment connection area during the healing. After a prescribed healing period (3-6 months), a second-stage procedure may be performed to expose the implant and to remove the cover screw & then to attach a healing abutment to the implant body for initial soft tissue healing. This healing abutment is termed a permucosal extension because it extends the implant above the soft tissue and results in the development of a permucosal seal around the implant.

Primary impression: Seven to 10 days after second phase surgery, preliminary impression of maxilla and mandible are made using an alginate impression material in stock edentulous tray. The impression is casted in dental stone and trimmed for the preparation of the special tray fabrication.

Final impression: Making a master impression is necessary to transfer the position and design of the implant body or abutment to a master cast for prosthesis fabrication. A special tray is fabricated & used especially when there is bone resorption, limited mouth access, low inter-arch distance & gag reflex. Otherwise, a stock tray can be used for taking the final impression.

A transfer coping (impression post) is used to position an analogue for implant body or abutment in an impression. Two basic implant restorative techniques are used to make a master impression, and each uses a different design transfer coping based on the transfer impression technique performed which is either close or open tray transfer technique.

Close tray impression technique: this technique is specifically used when the implants are sufficiently parallel to each other and when there is small inter-arch distance (not enough for the long copings of the open tray impression technique). Indirect transfer copings are screwed into the abutment or implant body. Light body elastomer impression material is injected around the impression copings and a **"closed tray"** is seated after being filled with heavy body elastomer. After the impression is set & removed, the copings are unthreaded from the implant bodies, connected to implant body analogues, and reinserted into the impression before pouring of the cast (Fig 7). The indirect

transfer copings are usually slightly tapered to allow ease in removal of the impression and often have flat sides or smooth undercuts to facilitate reorientation in the impression after it is removed from the mouth. Close tray impression technique is easier, less time consuming & simpler to capture than the open tray technique.

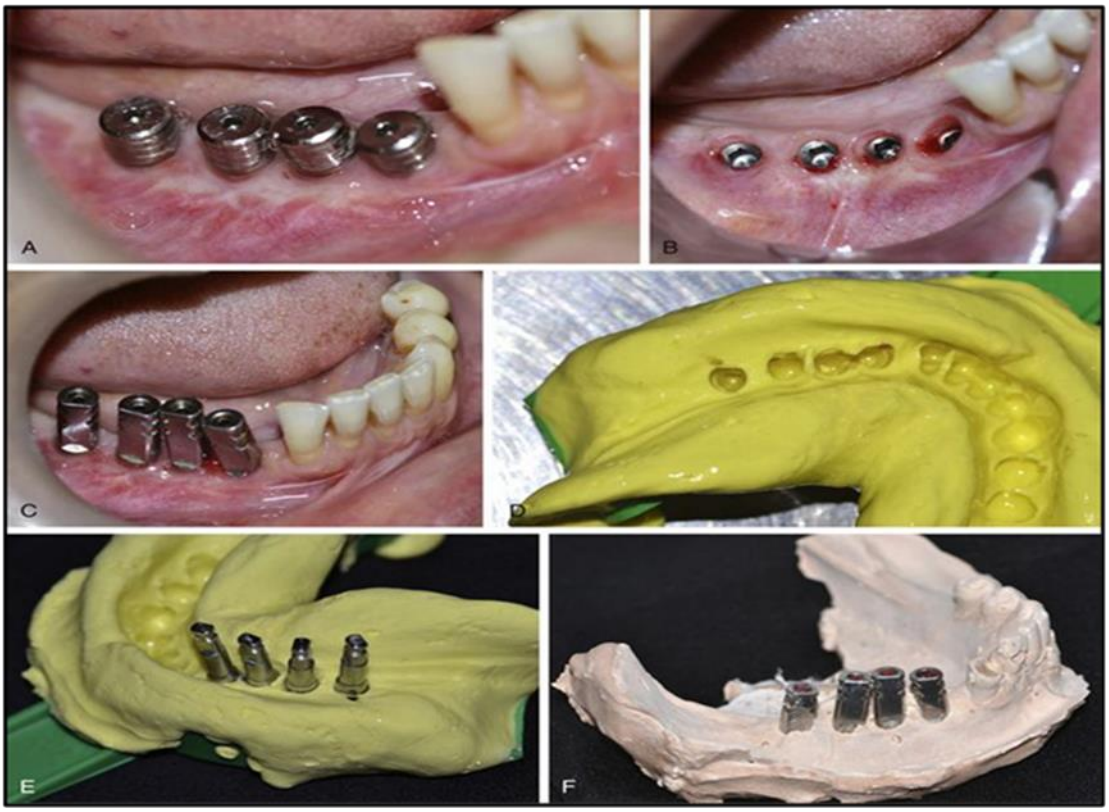

Figure 7: Healing abutments (A) are removed (B) and the impression posts are inserted (C). A closed tray impression is made (D). The posts are unthreaded, assembled with analogues & inserted into the impression (E). Stone cast (F).

Open tray impression technique: this technique uses a direct transfer coping which usually consists of a square transfer component to resist rotation and displacement in the impression material and a long central screw to secure it to the abutment or implant body. An **"open tray"** (special or perforated plastic stock tray) is used to permit direct access to the long central screw of the transfer coping. The open window tray is tried in the mouth for comfort and path of insertion. After the heavy body elastomer impression material is loaded into the tray, the light body elastomer impression material is injected around the impression copings, and the tray seated. After the impression material is set, the direct transfer coping screw is unthreaded with a screwdriver to allow removal of the impression from the mouth with the attached copings

(Fig 8). Using of direct transfer copings is considered more accurate than indirect ones because they eliminate the error of impression permanent deformation as they remain within the impression until the master model is poured and separated.

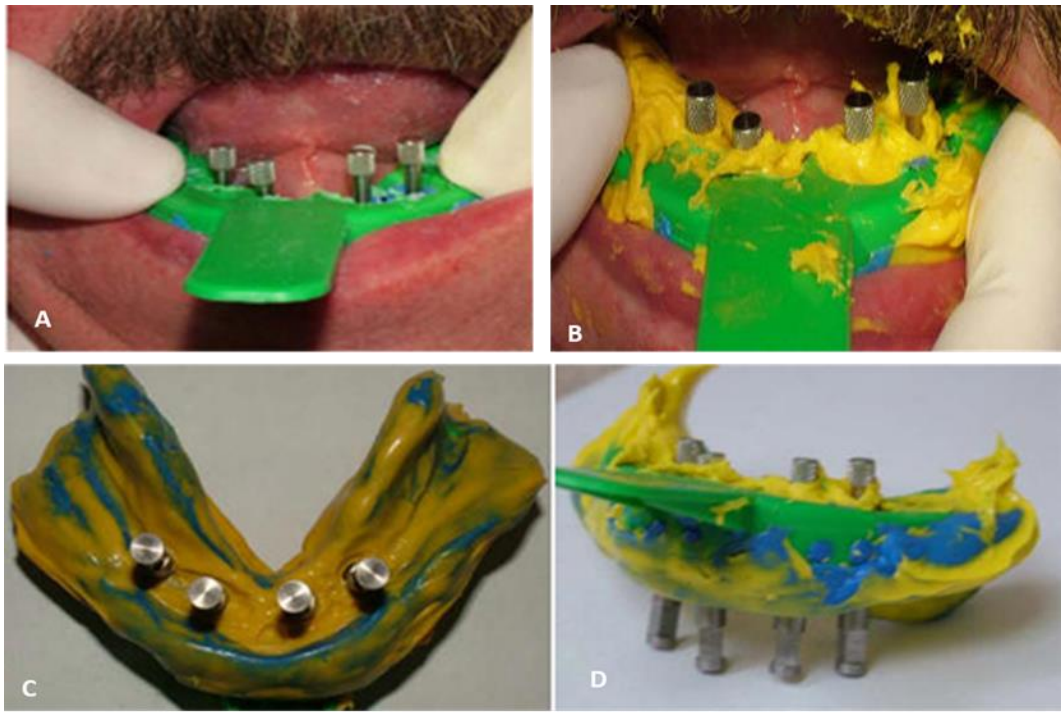

Figure 8: A. Open tray customized and checked in the mouth while impression copings are attached to the implant bodies, B. Impression is taken, C. the impression is removed with the attached copings, D. implant analogues are screwed onto the copings to be prepared for cast fabrication.

Prosthetic abutment: after the master cast is obtained, the impression copings are removed from the cast and replaced with abutments which are attached to the analogues & sent to the lab for prosthesis fabrication. Three main categories of implant abutments are described: (1) an abutment for screw retention uses a screw to retain the prosthesis or superstructure (2) an abutment for cement retention uses dental cement to retain the prosthesis or superstructure, and (3) an abutment for attachment uses an attachment device to retain a removable prosthesis.