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Prosthetic Options in Implant Dentistry

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Certification of the Supervisor

I certify that this project entitled " **Prosthetic Options in Implant Dentistry**" was prepared by the fifth-year student **Ali Hayder Kadhim** under my supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

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Dedication

This review is dedicated to my dearest family and friends who supported me through long journey in university.

Acknowledgement

This review was not possible it is wasn't for my supervisor, who led me through the challenges of writing this paper.

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List of Abbreviations

- FP: fixed prosthesis
- RP: removable prosthesis
- CAD: computer-aided design
- CAM: computer-aided manufacturing
- CT: computed tomography
- OD: overdenture
- FPP: fixed partial prosthesis
- PFM: porcelain-fused to metal
- IAC: integrated abutment crowns
- GPC: gold porcelain crowns

Introduction

Dental implantology is the practice of inserting alloplastic materials into patient's jaw bone for purpose of support and retention of prosthetic replacement of missing teeth. Implant-supported prostheses offer a more predictable treatment course than conventional restorative options. Implants create a custom foundation that fits a pre-determined prosthetic result. (Gowd et al., 2017)

Implant placement is a reconstructive pre-prosthetic surgical procedure, with primary aim to enhance function, esthetics and social rehabilitation with a prosthetic replacement of missing teeth, rather than removal of pathology as other conventional surgical procedures. (Mericske-Stern, 2008)

Patients are dissatisfied with complete dentures with complaints ranging from loose dentures, sore spots and inability to eat certain foods. The WHO stated that minimal standard of care for patients with complete edentulism in mandible is an overdenture supported by two implants. (Tunkiwalla et al., 2020)

Although implant insertion is important, it is not the end goal of the treatment, rather it is the replacement of lost tooth form, function, esthetics, speech and health. (Misch, 2006)

Implant-retained prosthesis design is mandatory to outline before determining the plan for bone, implant bodies and implant abutments. (Misch, 1988)

The goals of implant dentistry are to replace a patient's missing teeth to normal contour, comfort, function, esthetics, speech, and health,

regardless of the previous atrophy, disease, or injury of the stomatognathic system. It is the final restoration, not the implants, that accomplish these goals. In other words, patients are missing teeth, not implants. To satisfy predictably a patient's needs and desires, the prosthesis should first be designed. In the stress treatment theorem, the final restoration is first planned, similar to the architect designing a building before making the foundation. Only after this is accomplished can the abutments necessary to support the specific predetermined restoration be designed. (Misch, 2015)

Aims of Study

The aims of implant dentistry are:

- 1- To replace a patient's missing teeth to normal contour, comfort, function, esthetics, speech, and health, regardless of the previous atrophy, disease, or injury of the stomatognathic system.
- 2- It is the final restoration, not the implants, that accomplish these goals.
- 3- To satisfy predictably a patient's needs and desires, the prosthesis should first be designed. In the stress treatment theorem.

Chapter One: Review of Literature

1.1. Definition

Dental implant technology is continuously evolving with established and new systems undergoing further development. It is beyond the scope of this chapter to provide a detailed description of the different implant systems, but a fundamental discussion will be provided.

An implant restoration consists of three components (Fig. 17-1):

1. The implant fixture, which is placed in the bone and becomes osseointegrated
2. An abutment, which is a prosthetic transmucosal extension
3. A restoration, which is cemented (cement retained) or is part of the abutment and attached directly to the implant fixtures by an internal screw (screw retained) (Arteaga, 2015)

1.2. Treatment Planning

The first step is to visualize the final restoration design. Then locate areas of key implant support. Then analyze the patient's force factors and bone density are taken into consideration. Then, additional implants to support such expected forces are planned, along with implant size and design to match forces expected and area of support present. This indicates the flow of treatment, as the factors interplay, a deficiency of bone, for example, would indicate either modification of available supporting anatomy or altering the patient's expectations for the prosthesis. (Glücker et al, 2020)(Wang et al, 2019).

Because the primary causes of complications in implant dentistry are related to biomechanics, Misch developed a treatment plan sequence to decrease the risk of biomechanical overload, consisting of the following steps: (Misch, 2015)

1. Prosthesis design
2. Patient force factors
3. Bone density in the edentulous sites
4. Key implant positions
5. Implant number
6. Implant size
7. Available bone in the edentulous sites
8. Implant design

1.3. Removable vs Fixed Restorations

1.3.1. Removable Restoration

1.3.1.1. Indications

In a completely edentulous patient, implant support removable prosthesis is often the treatment because of reduced cost, due to fewer number of implant fixtures needed, as some support is derived from soft tissues. This, most of the time, involves insertion of implants in the anterior region, reducing the need for bone augmentation and with the primary goal of providing denture retention. This is due to the fact that anterior alveolar ridges present with greater residual height and 4 times slower rate of resorption after tooth loss than posterior regions. This fact

not only reduce the cost of treatment but also is not stalled for 4 months to allow bone graft to mature.

1.3.1.2. Advantages

Removable prostheses also restore lost soft tissue by facial flanges which enhance esthetics especially in maxillary anterior region but restoring proper lip support. These appliances also provide the patient with the possibility of removing the appliance. This benefits the patient in case of hygiene maintenance, prevention of nocturnal parafunction and sending the prosthesis to the laboratory for correction of complications. (Goodacre et al, 2003)

The majority of the studies which evaluate the implant-supported overdentures reported that the failed implants were commonly observed in the maxilla in comparison with the mandible as observed in the present study. The majority of the failures was associated with severe peri-implantitis. (Klemetti et al, 2003)

1.3.2. Fixed Restoration

1.3.2.1. Indications

On the other end of the spectrum, fixed prostheses present an array of benefits. One major episode is the psychological advantage of fixed teeth. It also permits restoration of partially or completely-edentulous mouth with reduced crown height space to accommodate a superstructure and a removable prosthesis.

1.3.2.2. Advantages

Fixed prosthesis also lasts longer and exhibit fewer complications than removable prostheses since the later require replacements of attachments and more rapid wear of acrylic denture teeth than porcelain. (Goodacre et al, 2003)

It also eliminates the problem of food entrapment under the soft tissue extensions of the removable prostheses. (Jacobs et al, 2019)

1.3.2.3. Disadvantages

The most common complication of a cement-retained implant restoration is residual cement left in the gingival sulcus of the implant. Residual cement in the sulcus after cementation of the prosthesis is a source of periimplantitis. The occurrence of this complication is more often found with implants than natural teeth. (Misch, 2015)

1.4. Prosthetic options for Completely edentulous jaw

1.4.1. Fixed prosthesis

Early published restorations used a precious-metal alloy framework with acrylic veneering, in a so-called wrap-around technique of prefabricated acrylic denture teeth and denture base to compensate for hard and soft tissue loss. Such restorations were of hybrid design, supported by 4- 6 implants. These restorations used implants placed between the foramina to avoid maxillary sinus and mental nerve. Maxillary prostheses were scarce

due to advanced atrophy and anatomical limitations. They also suffered from fracture of cantilever designs. (Mericske-Stern, 2008)

Fixed prostheses are limited by their high cost, esthetic problems as in long teeth and absence of natural soft tissue contour, and need for congruent implant position for passive fit and screw-retention of prosthesis. It also provides sub-optimal lip support in maxilla. (Mericske-Stern, 2008)

Present designs use titanium and ceramics. Ceramics are used without titanium support for single tooth replacements and short span fixed partial prostheses. (Mericske-Stern, 2008)

CAD/ CAM provides quality and precision of restorative materials, where is utilizes uniform blocks of materials dispensed without heat. A technical improvement would be to eliminate implant abutments from superstructure design and connect the framework directly to implant

shoulder. This offers less tensile shear stress in the superstructure, protecting it from fracture and the veneer from chipping. (Mericske-Stern, 2008).

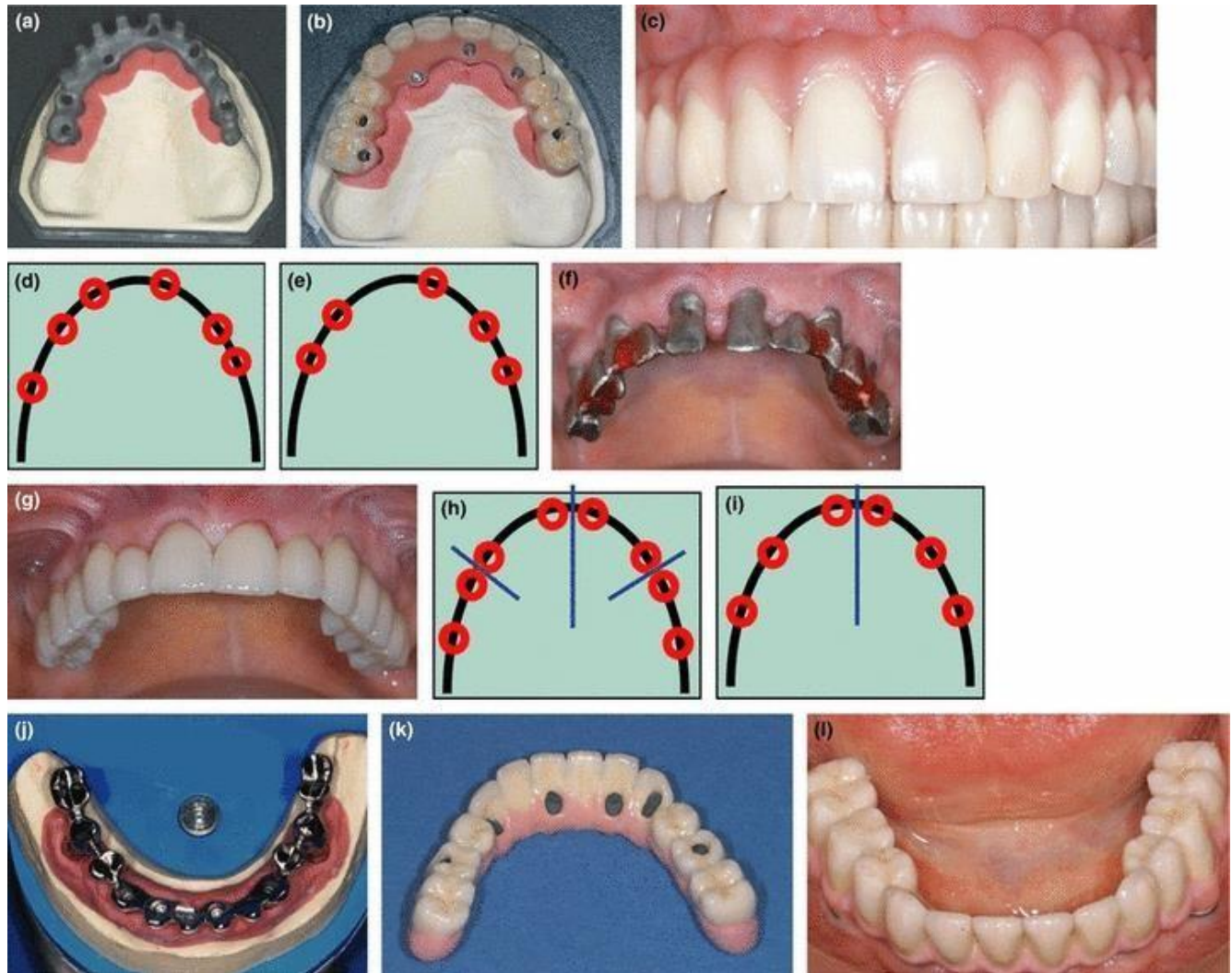


Figure 1.1 Fixed prosthesis, edentulous jaw. (a) Fixed cantilever prosthesis with CAM titanium framework on 6 implants. (b) Wrap-around technique, extremely light weight of prosthesis (18 g). (c) Aesthetic appearance. (d) and (e) Graphic illustrations: possible distribution of 5–6 implants for fixed cantilever prosthesis (CAD-CAM technology and titanium framework with wrap-around technique). (f) Fixed metal framework for ceramometal bridgework. (g) Full-arch bridgework, with 6–8 implants, clinical view, increased weight (86 g). (h) and (i) Graphic illustrations: Distribution of 6–8 implants and possible segmentation of framework. (j) CAD-CAM titanium framework. (k) Mandibular fixed prosthesis supported by 6 implants. (l) Titanium framework with ceramic veneering. (R. Mericske-Stern, 2008).

Chipping of the ceramic is described as either minor chipping or polishable which is repairable, and major or catastrophic chipping,

which is not repairable leads to failure of the prosthesis. (Morton et al., 2018).

Integrated abutment crowns (IACs) or gold porcelain crowns (GPCs) were used, and the prosthesis type was a single crown or a fixed dental prosthesis. The incidence of complications for IACs is significantly higher than that for GPCs. (Gao et al., 2021)

Porcelain-metal (PFM) restoration introduces the problem of metal bulk beneath porcelain to keep the latter in its ideal thickness of 2mm. This bulk of metal acts as a heat sink during casting, resulting in porosities that compromise strength and make it liable to fracture during loading. (Gowd et al., 2017)

PFM lacks the biocompatibility of zirconia. (pelivan , 2022)

Hybrid restorations option has acrylic intermediating between porcelain and metal sub-structure, so as to reduce loading force during mastication. As a general rule, such option is used for implants with large crown height. (Gowd et al., 2017)

1.4.2. Over-Denture

Overdentures are a preferred treatment modality for elderly patients with maladaptive mandibular dentures. The basic principle utilizes four inter-foraminal implants with a bar framework for support of denture. The number of implants was disputed with regards towards effectiveness, between 2 and 4, with no clear advantage of one over the other. (Mericske-Stern, 2008).

The type of retention rigid bars and resilient as in single ball anchors or rotational bars. The latter type provides mixed implant-soft tissue support when used with two inter-foraminal implants. Long-term maintenance was shown to be greater in resilient retention mechanism than rigid. Flexible clip bars also reported greater incidence of complications than single ball anchors. (Mericske-Stern, 2008).

Some types of mandibular overdenture reported bone resorption in posterior region in some studies, while other studies of cantilever dentures reported posterior mandibular bone apposition. (Mericske-Stern, 2008).

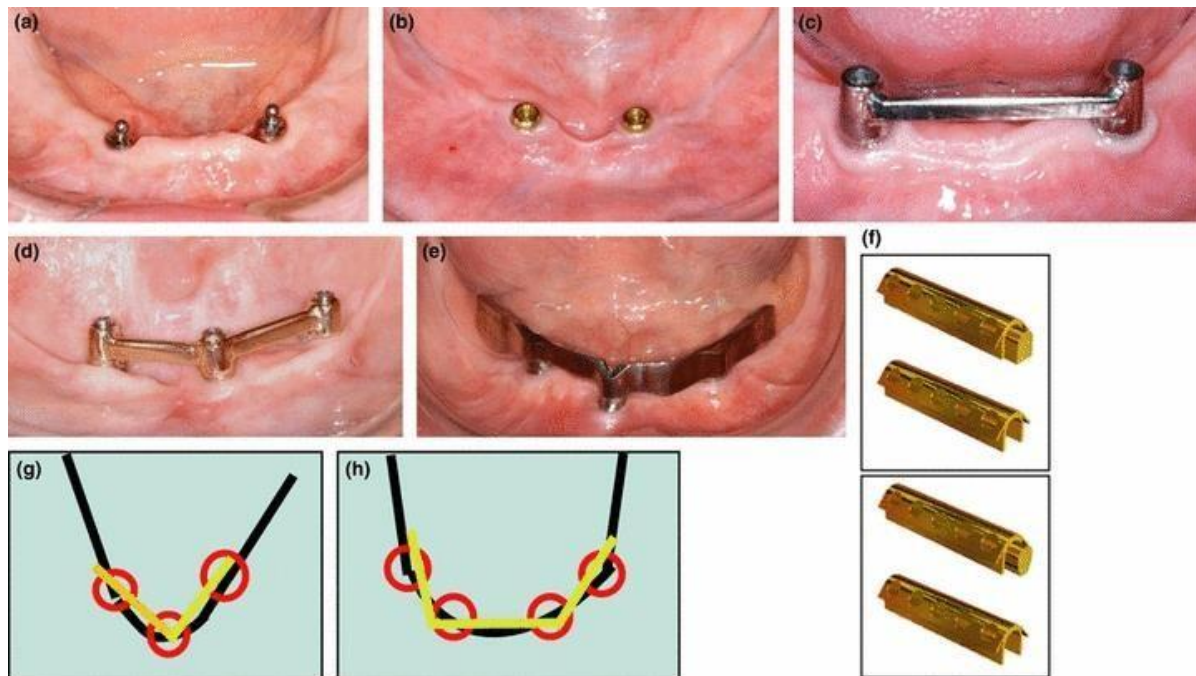


Figure 1.2 Overdentures mandible. (a) and (b): Single anchors: ball anchors, locators. (c) Soldered bar, gold alloy on 2 implants. (d) On 3 implants, with more pronounced anterior curvature. (e) Alternative: milled bar from titanium (CAD-CAM). (f) Dolder bars: egg shaped, u-shaped. (g) and (h) Graphic illustrations: with a V-shaped jaw or large anterior curvature, 3 or 4 implants are suggested. The single bar segments should have a length of ≥ 15 mm. Mericske-Stern, 2008).

Overdentures in maxilla are prone to biologic failure due to bone osteoporosis and alveolar bone atrophy. Thus, for such cases, implants used are of limited number and small size. Often, such cases are the aftermath of failed implant-retained fixed prostheses converted into overdentures.

Implant distribution at 2 in number is insufficient, and is regarded as temporary solution with full palatal coverage. A bar connecting the two implants in maxilla is not feasible due to insufficient stability. A design of better prognosis is to use 4-5 implants with a connecting bar of horse-shoe shape with the reinforcement of denture base by a metal framework. (Mericske-Stern, 2008).

Implants inserted tend to have divergence of axes due to anatomical limitations. This hinders vertical insertion in a single path, which can be compensated by providers for single ball anchors, up to 40°. An overdenture retained by a metal bar supported by 4-5 implants distributed according to anterior arch curvature provides support that mimics fixed prosthesis, biomechanically. (Mericske-Stern, 2008).

Soldered gold alloy bars are liable for fracture. Such problem can be overcome by CAD/ CAM technology offering titanium bars. (Mericske- Stern, 2008).

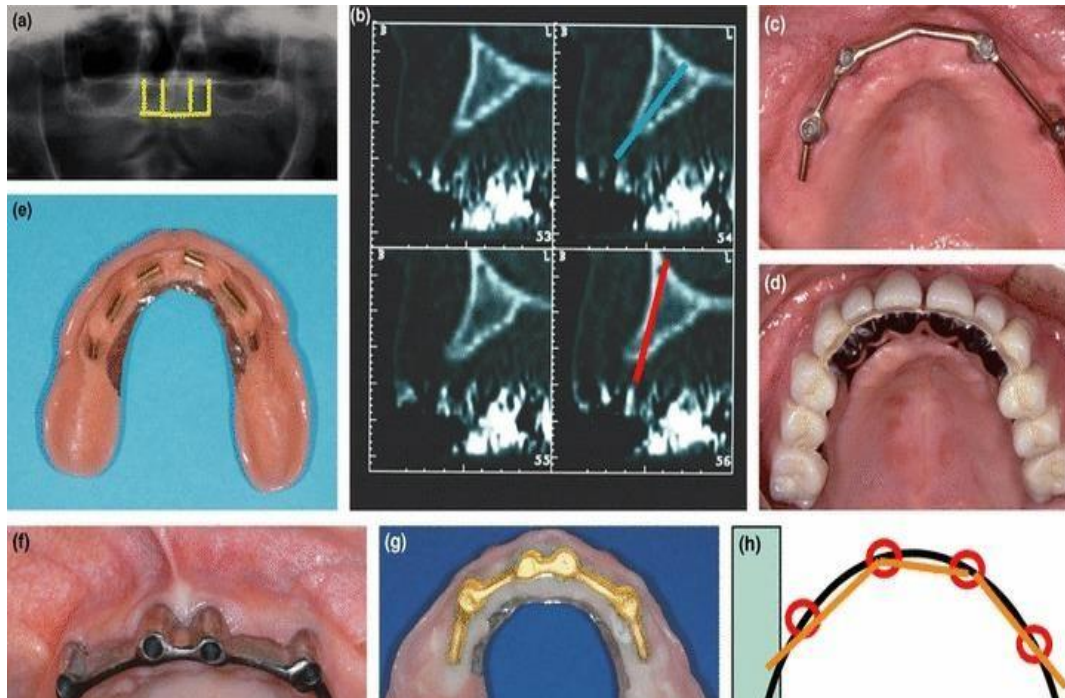


Figure 1.3 Overdentures maxilla. (a) Orthopantomogram: 4 implants with bar planned in the anterior region between first premolars or canines, no conflict with sinus. (b) CT slice: buccally oriented implant axis (blue) – compatible with bar, a more vertical axis (red) must be planned for fixed prosthesis with screw retention. (c) Soldered bar, gold alloy with 4 implants, large distance between both anterior implants, bar with angulation.

(d) and (e): Horseshoe OD with reinforced with metal framework. (f): Milled bar from titanium (CAD-CAM). (g): Galvanoforming female retainer. (h) Graphic illustration: Distribution of implants, 2 anterior implants should preferably be in rather close position, otherwise bar will not follow anterior curvature or must be slightly bended (c). (Mericske-Stern, 2008)

Speech analysis revealed better speech with overdentures than fixed prostheses. On the other hand, soft tissue problems such as inflammation and hyperplasia are seen in bar-stabilized overdentures. (Mericske-Stern, 2008).

1.5. Prosthetic options for partially-edentulous jaw

There are 3 basic considerations to bear in mind regarding implant-supported fixed partial prosthesis, (Mericske-Stern, 2008).

- Removable partial dentures are avoided for Kennedy class I and II cases and anterior edentulous spans (Mericske-Stern, 2008).
- No need to involve adjacent healthy teeth (Mericske-Stern, 2008).
- Solves the problem of tooth-supported FPP with posterior cantilevers (Mericske-Stern, 2008)..

There has occurred a paradigm shift from conservation of tooth when broken down or endodontically-treated for support of a FPP, to extraction and implant placement. (Mericske-Stern, 2008).

Long replacement teeth are used in posterior region to compensate lost hard and soft tissue which is allowed due to the low critical esthetic importance. (Mericske-Stern, 2008).

FPP offers no cross-arch stabilization yet yields a good prognosis.

Despite centric and eccentric loads expected for posterior region, there was no statistically-significant difference between survival rates in anterior and posterior sites. (Mericske-Stern, 2008).

Although some clinicians suggest a staggered configuration of multiple implants as being better than cantilever implants with similar configuration to tooth-supported FPP, none was proven superior. (Mericske-Stern, 2008).

In general, combined implant and tooth-support for FPP is avoided due to frequent technical problems. (Mericske-Stern, 2008).

Custom-made implant abutments are available for retention of FPP in combination with screw-retention or cementation. Though, passive fit is a problem for conventionally-fabricated FPP framework. Moreover, cementation yields easier passive fit but with greater gaps from crown margin, while screw-retention has a more precise fit with narrow gaps for crown margin but greater framework tension. (Mericske-Stern, 2008).

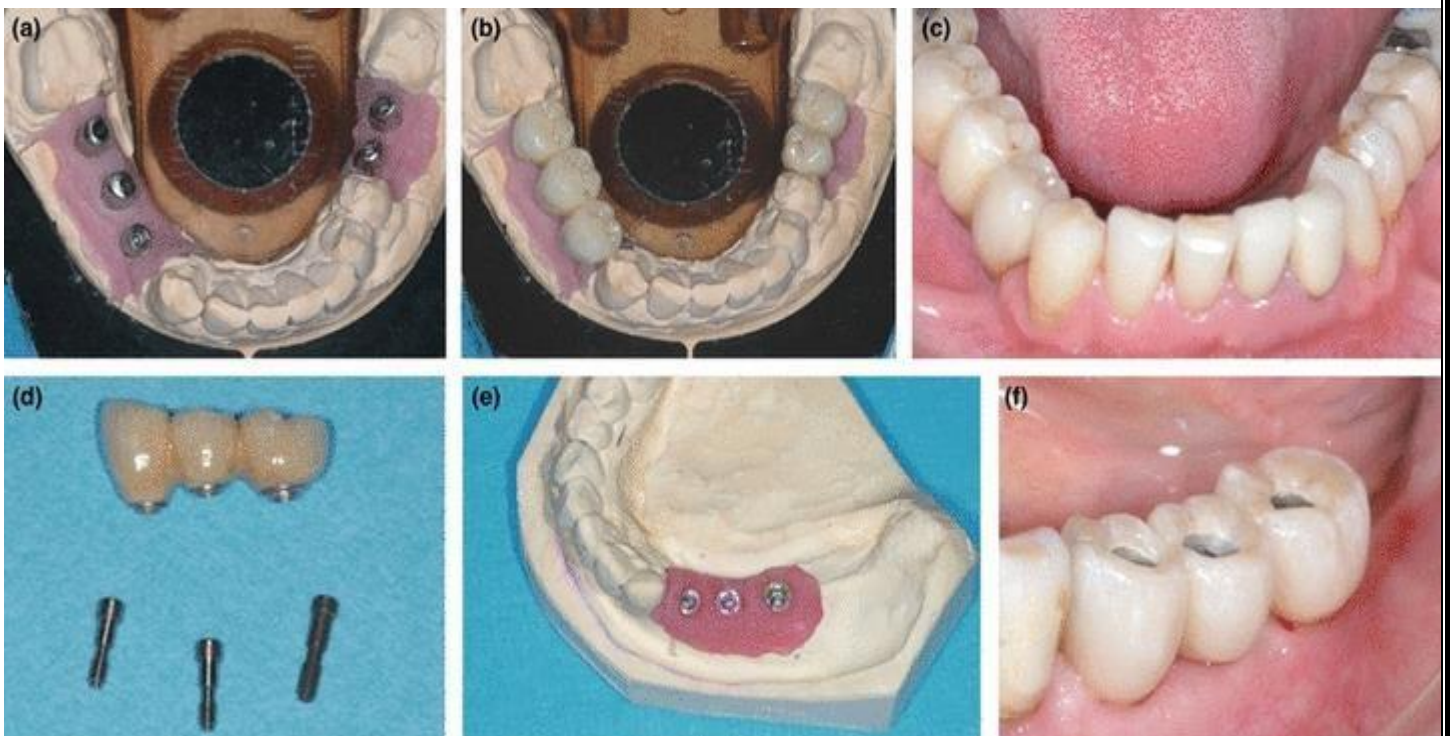


Figure 1.4 Fixed partial prosthesis, large gap or distal extension (FPP, ceramometal). (a) 3 and 2 missing teeth are replaced by 3 respectively 2 implants titanium abutments. (b) FPP on 2 and 3 implants each on the cast, no access hole for occlusal screw. (c) Cemented, clinical view. (d) 3 connected, screw retained crowns. (e) Distal free-end situation left mandible. (f) Screw retention, occlusal access hole visible, clinical view. (Mericske-Stern, 2008)

Single crowns retained by implants show high survival rates due to small space allowing better design of occlusal scheme to restrict heavy centric contacts and avoid lateral guidance by adjacentteeth protection. It is frequently used in aesthetic zone of anterior maxilla thus requires creation of proper gingival form and following of biological principles. (Mericske-Stern, 2008)

Frameworks for single crowns or FPP can be also made of zirconium or high strength all ceramic materials. Zirconia framework is screw-retained compared to possibility of cementation with ceramics. Zirconium is stronger than all ceramics, but require precise CAD/ CAM fabrication to prevent a greyish gingival border, as seen with ceramometal crowns, due tot the fact that zirconium is extremely white and not translucent. (Mericske-Stern, 2008).

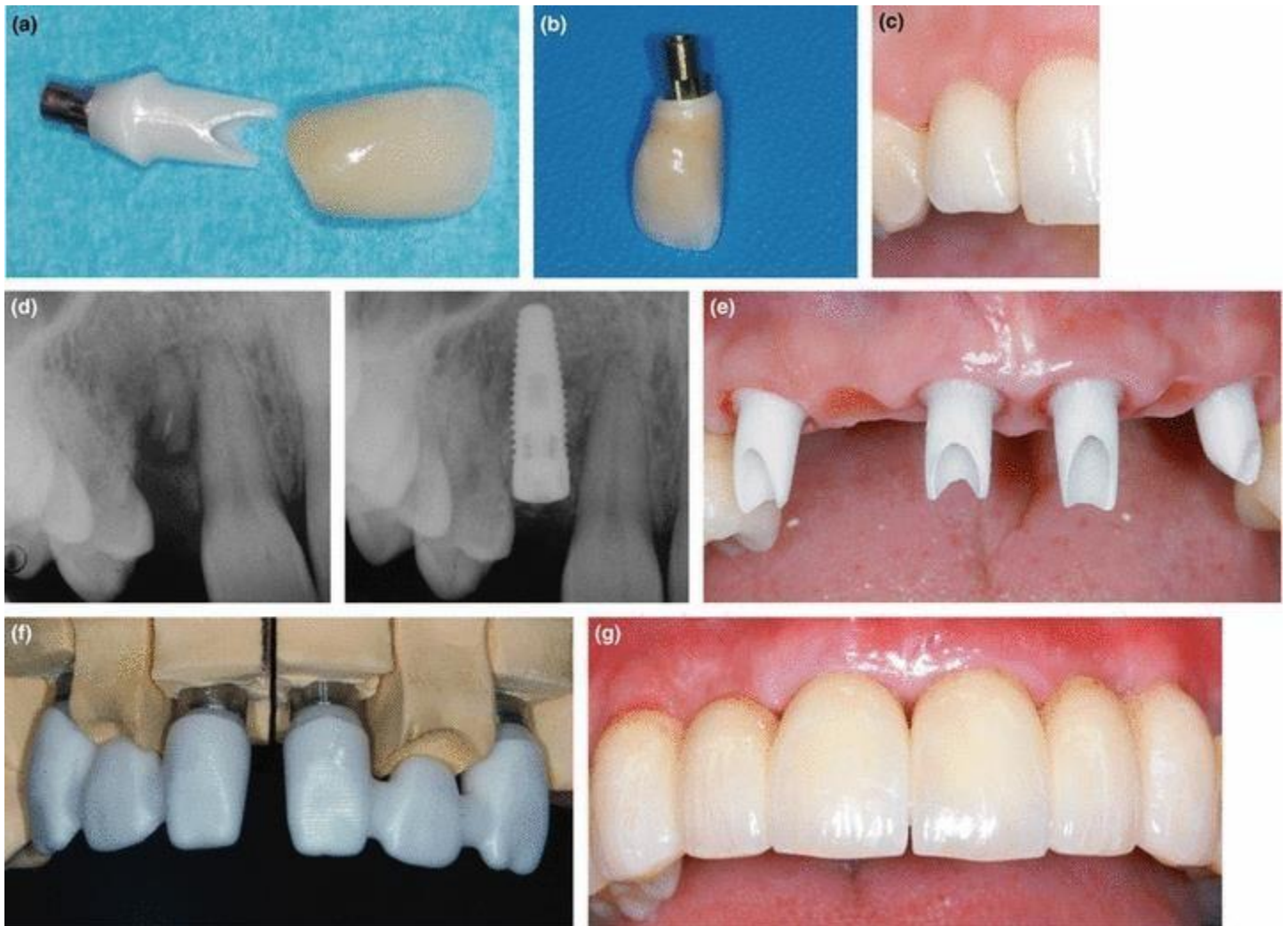


Figure 1.5 Zirconia, CAD-CAM fabrication. (a) Zirconia abutment with ceramic crown for cementation. (b) Zirconia crown, screw retention in the aesthetic zone. (c) Zirconia crown on implant, replacing missing lateral incisor, clinical view with good aesthetic result. (d) Radiographic illustration before and after, bone height favourable at adjacent neighbouring teeth. (e) Zirconia abutments in anterior maxilla for cementation of short span FPP from zirconia. (f) Zirconia framework, on cast. (g) 3- unit cemented zirconia bridgework, 2 segments, clinical view. (Mericske-Stern, 2008)

1.6. Prosthetic Options

Misch proposed five prosthetic options for implant dentistry. The first three options are FPs. These three options may replace partial (one tooth or several) or total dentitions and may be cemented or screw retained. They are used to communicate the appearance of the final prosthesis to all of the implant team members, including the laboratory and patient. These options depend on the amount of hard and soft tissue structures replaced and the aspects of the prosthesis in the esthetic zone. Common to all fixed options is the inability of the patient to remove the prosthesis.

Two types of final implant restorations are RPs; they depend on the amount of implant support, retention, and stability, not the appearance of the prosthesis. (Misch, 2015).

Table 1.1 Misch's **five** prosthetic options for implant dentistry. (Misch, 2015).

Type	Definition
FP-1	Fixed prosthesis; replaces only the crown; looks like a natural tooth
FP-2	Fixed prosthesis; replaces the crown and a portion of the root; crown contour appears normal in the occlusal half but is elongated or hyper contoured in the gingival half
FP-3	Fixed prosthesis; replaces missing crowns and gingival color and a portion of the edentulous site; prosthesis most often uses denture teeth and acrylic gingiva but may be porcelain to metal
RP-4	Removable prosthesis; overdenture supported completely by implants (usually with a superstructure bar)
RP-5	Removable prosthesis; overdenture supported by both soft tissue and implants (may or may not have a superstructure bar)

1.6.1. Fixed Prosthesis

1.6.1.1. FP-1

An FP-1 is a fixed restoration and appears to the patient to replace only the anatomical crowns of the missing natural teeth. To fabricate this restoration type, there must be minimal loss of hard and soft tissues. The volume and position of the residual bone must permit ideal placement of the implant in a location similar to the root of a natural tooth. (Misch, 2005).

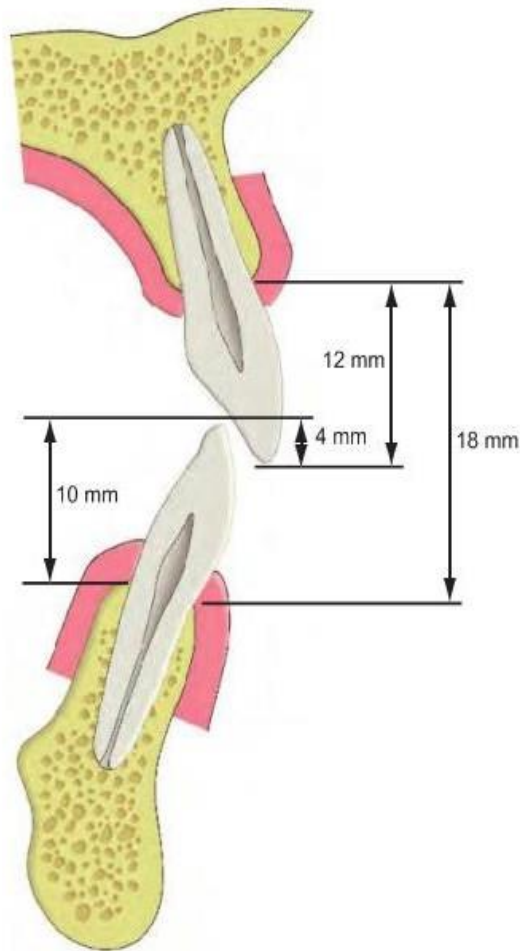


Figure 1.6 The healthy natural teeth have abundant bone and ideal soft tissue. The ideal hard and soft tissue allows ideal esthetics. (Misch, 2005).

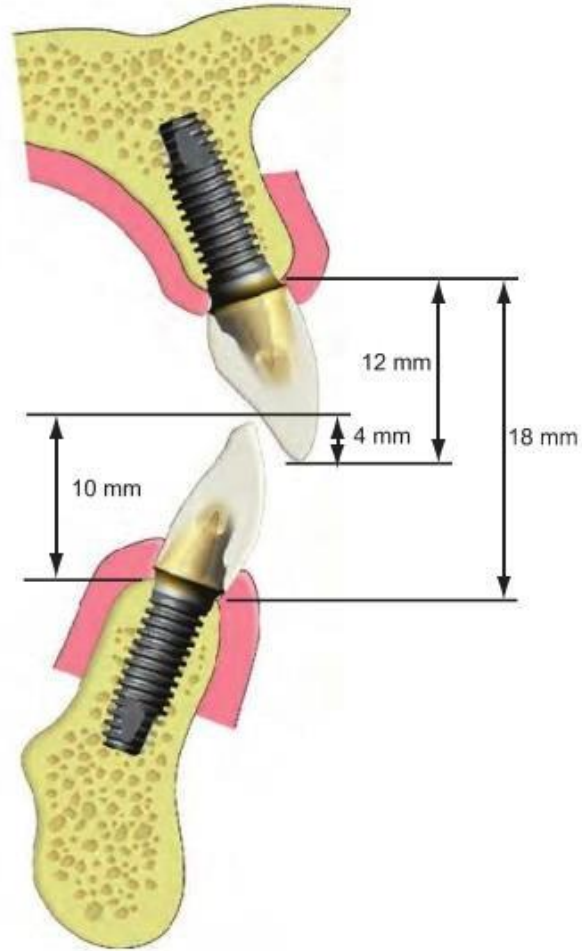


Figure 1.7 The bone and soft tissue must be ideal in volume and position to obtain an FP-1 appearance for the final restoration. When multiple teeth are replaced, bone and tissue augmentation is usually required to obtain an FP-1 prosthesis. (Misch, 2005)

The final restoration appears very similar in size and contour to most traditional FPs used to restore or replace natural crowns of teeth. The FP-1 prosthesis is most often desired in the maxillary anterior region, especially in the esthetic zone during smiling. (Misch, 2005).



Figure 1.8 A, An implant is positioned in the maxillary right canine position. The hard and soft tissue conditions are ideal for a crown of normal contour and size. B, The maxillary right canine implant crown in position. The soft tissue drape is similar to a natural tooth, and the crown contour is similar to the clinical crown contour of a natural tooth. This is the goal of an FP-1 prosthesis. (Misch, 2005).

The final FP-1 restoration appears to the patient to be similar to a crown on a natural tooth. However, the implant abutment can rarely be treated exactly as a natural tooth prepared for a full crown. The cervical diameter of a natural tooth is approximately 6.5 to 10.5 mm with an oval to triangular cross-section. However, the implant abutment is usually 4 to 5 mm in diameter and round in cross-section. In addition, the placement of the implant rarely corresponds exactly to the crown-root position of the original tooth. The thin labial bone lying over the facial aspect of a maxillary anterior root remodels after tooth loss and the crest width shifts to the palate, decreasing 40% within the first 2 years. The occlusal table of the crown should also be modified in unesthetic regions to conform to the implant size and position and to direct vertical forces to the implant body. For example, posterior mandibular implant-supported prostheses have narrower occlusal tables at the expense of the buccal contour because the implant is smaller in diameter and placed in the central fossa region of the tooth. (Misch, 2005).

Maxillary posterior teeth often have reduced occlusal tables from the palatal aspect because the buccal cusp is often within the esthetic zone. (Tjanet al, 1984).



Figure 1.9 This full-arch prosthesis has posterior crown contours that are narrower than natural teeth, because the implant is smaller in diameter than the tooth. As a general rule, the maxillary arch has reduced lingual contours and the mandibular posterior prosthesis has reduced buccal contours. (Tjan et al, 1984)

The width or height of the crestal bone is frequently lacking after the loss of multiple adjacent natural teeth; therefore, bone augmentation is often required before implant placement to achieve natural-looking crowns in the cervical region. There are no interdental papillae in edentulous ridges; therefore, soft tissue augmentation also is often required to improve the inter-proximal gingival contour. Ignoring this step causes open “black” triangular spaces (where papillae should usually be present) when the patient smiles. FP-1 prostheses are especially difficult to achieve when more than two adjacent teeth are missing. The

bone loss and lack of interdental soft tissue complicate the final esthetic result, especially in the cervical region of the crowns. The restorative material of choice for an FP-1 prosthesis is porcelain to noble-metal alloy. A noble-metal substructure can easily be separated and soldered in case of a nonpassive fit at the metal try-in, and noble metals in contact with implants corrode less than nonprecious alloys. Any history of exudate around a subgingival base metal margin will dramatically increase the corrosion effect between the implant and the base metal. A single tooth FP-1 crown may use aluminum oxide cores and porcelain crowns or ceramic abutments and porcelain crowns. However, the risk of fracture may increase with the latter scenario because impact forces are greater on implants than natural teeth. (Tjan et al, 1984).

1.6.1.2. FP-2

An FP-2 fixed prosthesis appears to restore the anatomical crown and a portion of the root of the natural tooth. The volume and topography of the available bone are more apical compared with the ideal bone position of a natural root (1-2 mm below the cement-enamel junction) and dictate a more apical implant placement compared with the FP-1 prosthesis. As a result, the incisal edge of the restoration is in the correct position, but the gingival third of the crown is overextended, usually apical and lingual to the position of the original tooth. These restorations are similar to teeth exhibiting periodontal bone loss and gingival recession. (Tjan et al, 1984).



Figure 1.10 A, An FP-2 prosthesis has longer clinical crowns than healthy natural teeth. The soft tissue drape is also reduced around the prosthesis. B, The FP-2 prosthesis appears of normal contour in the esthetic zone during a high smile and/or speech. (Tjan et al, 1984).

The patient and the clinician should be aware from the onset of treatment that the final FP-2 prosthetic teeth will appear longer than healthy natural teeth (without bone loss). The esthetic zone of a patient is established during smiling in the maxillary arch. (Tjan et al, 1984)

The number of teeth displayed in a smile is variable. Fewer than 10% of the population limits their smile to the anterior six teeth. Almost 50% of people show up to the first premolar. Only 4% of our patients display almost all the maxillary teeth during a smile. If the teeth do not show during smiling or speech, an FP-2 restoration is not a compromise. The low lip position is evaluated during sibilant sounds of speech (e.g., Mississippi). It is not unusual for patients to show less lower anterior teeth during smiling, especially in younger patients. Older patients are most likely to show the anterior teeth and gingiva during speech, with men showing more than women. Likewise, if the high lip line during smiling or the low lip line during speech does not display the cervical regions, the longer teeth are usually of no esthetic consequence, provided

that the patient has been informed before treatment. (Tjan et al, 1984)(Cade et al, 1979).



Figure 1.11 The number of teeth displayed in a smile may include the first molars (top) or be limited to the first premolar (bottom). The soft tissue is also observed around the teeth. (Tjan et al, 1984)(Cade et al, 1979)

As the patient becomes older, the maxillary esthetic zone is altered. Whereas only 10% of younger patients do not show any soft tissue during smiling, 30% of 60-year-old adults and 50% of 80-year-old adults do not display gingival regions during smiling (Tjan et al, 1984)(Cade et al, 1979).



Figure 1.12 A full-arch maxillary implant prosthesis. Note that the maxillary right anterior implant is in an embrasure. B, The maxillary full arch FP-2 restoration in place. C, The FP-2 prosthesis appears as natural teeth in the esthetic zone. D, The high smile line of the same patient. The low position of the maxillary lip during smiling permitted the fabrication of an FP-2 prosthesis. (Tjan et al, 1984)(Cade et al, 1979).

The low lip position of the mandibular lip during speech is not affected as much as the maxillary lip during the high smile line. Rarely do younger or middle-age patients show the lower gingival during speech. Only 10% of older patients show the mandibular soft tissue during speech. Hence, FP-2 restorations in the mandible are common and usually of no compromise (Tjan et al, 1984)(Cade et al, 1979).



Figure 1.13 An FP-2 complete mandibular fixed prosthesis from an occlusal view. The anterior teeth appear ideal in width and contour. (Tjan et al, 1984)(Cade et al, 1979)

A multiple-unit FP-2 restoration does not require as specific an implant position in the mesial or distal position because the cervical contour is not displayed during function. The implant position may be chosen in relation to bone width, angulation, or hygienic considerations rather than purely esthetic demands (compared with the FP-1 prosthesis). On occasion, the implant may even be placed in an embrasure between two teeth. This often occurs when replacing mandibular anterior teeth with a full-arch fixed restoration. If this occurs, the incisal two thirds of

the two crowns should be ideal in width, as though the implants were not present. Only the cervical region is compromised. Although the implant is not positioned in an ideal mesiodistal position, it should be placed in the correct facial-lingual position to ensure that contour, hygiene, and direction of forces are not compromised. (Brinemark et al, 1985).



Figure 1.14 Almost every implant is in the interproximal embrasure of this mandibular FP-2 restoration. The technician fabricated the incisal aspect of the restoration without regard to the mesiodistal position of the implants. (Brinemark et al, 1985)

The material of choice for an FP-2 prosthesis is precious metal to porcelain. The amount and contour of the metal work is different than for an FP-1 restoration and is more relevant in an FP-2 prosthesis because the amount of additional volume of tooth replacement increases the risk of unsupported porcelain in the final prosthesis, when the metal work is under-contoured. (Brinemark et al, 1985).

1.6.1.3. FP-3

The FP-3 fixed restoration appears to replace the natural teeth crowns and has pink-colored restorative materials to replace a portion of the soft tissue, especially the interdental papillae. As with the FP-2 prosthesis, the original available bone height has decreased by natural resorption or osteoplasty at the time of implant placement. To place the incisal edge of the teeth in proper position for esthetics, function, lip support, and speech, the excessive vertical dimension to be restored requires teeth that are unnatural in length. However, unlike the patient requirements for an FP-2 prosthesis, the patient may have a normal to high maxillary lip line during smiling or a low mandibular lip line during speech. As a consequence, the soft tissue drape should also be replaced. Prosthetic replacement of the soft tissue drape (FP-3 prosthesis) is most often desirable when multiple adjacent teeth are missing. (Tjan et al, 1984).

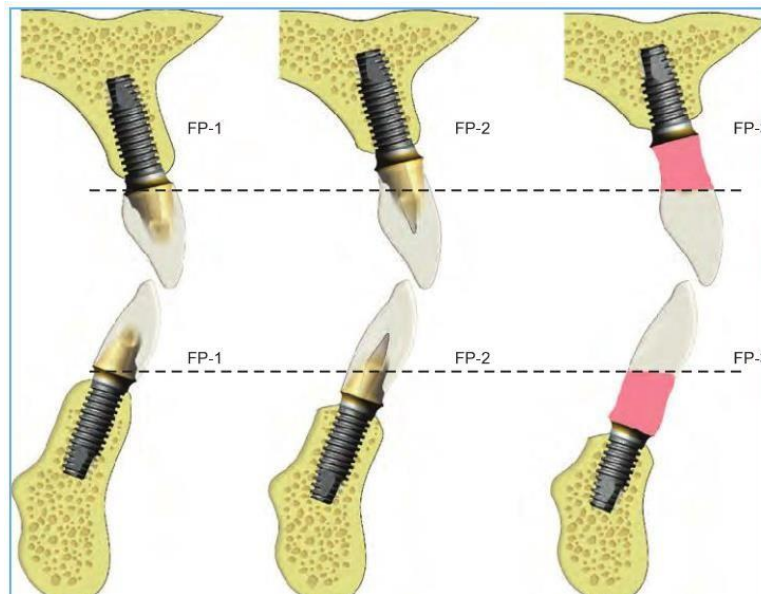


Figure 1.15 Fixed restorations have three categories: FP-1, FP-2, and FP-3. The restoration type is related to the contour of the restoration. (FP-1 is ideal, FP-2 is hyper-contoured, and FP-3 replaces the gingiva drape with pink porcelain or acrylic) The difference between FP-2 and FP-3 most often is related to the high maxillary lip position during smiling or the mandibular lip position during sibilant sounds of speech. FP-2 and FP-3 restorations often require more implant surface area support by increasing implant number or size. (Tjan et al, 1984).

The ideal high smile line occurs in almost 70% of the population and the maxillary lip displays the interdental papilla of the maxillary anterior teeth but not the soft tissue above the mid-cervical regions (Figure 18). (Tjan et al, 1984).

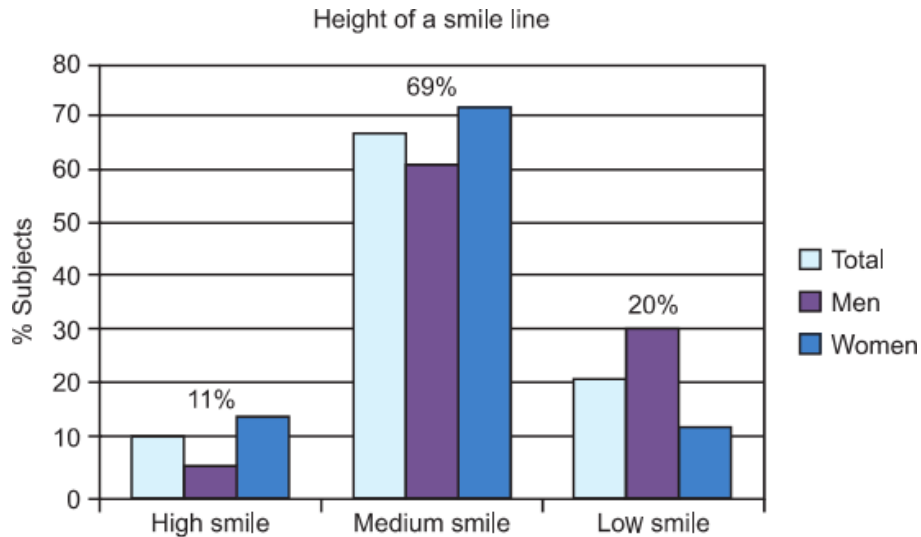


Figure 1.16 A smile that shows interdental papillae but no cervical tissue is ideal and found in 70% of patients. A low smile line shows no soft tissue during smiling and is seen in 20% of patients (more men than women). A high smile line displays interdental papillae and the cervical regions above the teeth and are observed in 11% of patients (women more often than men). (Adapted from Tjan AH, Miller GD, The JG: Some esthetic factors in a smile, J Prosthet Dent 51:24-28, 1984.)

Approximately 7% of men and 14% of women have a high smile or “gummy” smile and display the interdental papillae and at least some of the gingival tissues above the free gingival margin of the teeth. (Tjan et al, 1984).

Patients in both of these categories of high lip line should have the soft tissue replaced by either the prostheses or the patient's soft tissue. (Brinemark et al, 1985).



Figure 1.17 A, An intraoral view of a maxillary full arch FP-3 restoration shows how it replaces the interdental papillae with pink porcelain. B, The high maxillary lip line during smiling shows the interdental papillary regions in the anterior maxilla. Therefore, the fixed prosthesis replaces the gingival regions in the esthetic zone by soft tissue surgery or, as in this case, with the final restoration (FP-3). (Brinemark et al, 1985)



Figure 1.18 Maxillary and mandibular FP-3 prosthesis with pink porcelain on a porcelain-to-metal restoration. B, An intraoral view of the maxillary FP-3 prosthesis. The pink porcelain permits the teeth to appear as normal size. (Brinemark et al, 1985)

The patient may also have greater esthetic demands even when the teeth are out of the esthetic smile and speech zones. Patients complain that the display of longer teeth appears unnatural even though they must lift or move their lips in unnatural positions to see the covered regions of the teeth. As a result of the restored gingival color of the FP-3, the teeth have a more natural appearance in size and shape, and the pink restorative material mimics the interdental papillae and cervical emergence region (Figure 21). (Brinemark et al, 1985).



Figure 1.19 An FP-3 mandibular full arch fixed prosthesis. The teeth look of normal size, and the patient may want this option even though the soft tissue drape is not exposed during speech. (Brinemark et al, 1985)

The addition of gingival-tone acrylic or porcelain for a more natural FP appearance is often indicated with multiple implant abutments because bone loss is common with these conditions, and the soft tissue drape is more difficult to appear ideal. (Brinemark et al, 1985).



Figure 1.20 A, Two porcelain-to-metal fixed prostheses. The maxillary arch is an FP-3 prosthesis with pink porcelain. The mandibular arch has a full arch FP-2 restoration. B, The maxillary FP-3 prosthesis with pink porcelain on a porcelain-to-metal fixed prosthesis and FP-2 restoration in the mandible during with a smile to evaluate the maxillary lip position. (Brinemark et al, 1985)

There are basically two approaches for an FP-3 prosthesis:

- (1) a hybrid restoration of denture teeth and acrylic with a metal substructure'® (Brinemark et al, 1985)
- (2) a porcelain-metal restoration (Figure 23). An FP-3 porcelain-to-metal restoration is more difficult to fabricate for the laboratory technician than an FP-2 prosthesis. The pink porcelain is harder to make appear as soft tissue and usually requires more baking cycles. This increases the risk of porosity or porcelain fracture. (Misch, 2005)



Figure 1.21 A, An FP-3 porcelain-to-metal restoration in the maxilla and an FP-3 hybrid with acrylic—metal and denture teeth in the mandible. B, The maxillary FP-3 porcelain to metal and mandibular FP-3 hybrid prosthesis during a smile. (Misch, 2005)

The primary factor that determines the restoration material is the amount of crown height space.””® An excessive crown height space means a traditional porcelain—metal restoration will have a large amount of metal in the substructure because the porcelain thickness should not be greater than 2 mm thick. Otherwise, there is an increase in porcelain fracture. Precious metals are indicated for implant restorations to decrease the risk of corrosion and improve the accuracy of the casting because nonprecious metals shrink more during the casting process. However, the large amount of metal in the sub-structure acts as a heat sink and complicates the application of porcelain during the fabrication of the prosthesis. In addition, as the metal cools after casting, the thinner regions of metal cool first and create porosities in the structure. This may lead to fracture of the framework after loading. Furthermore, when the casting is reinserted into the oven to bake the porcelain, the heat is maintained within the casting at different rates; thus, the porcelain cool-down rate is variable, which increases the risk of porcelain fracture. In addition, the amount of precious metal in the casting adds to the weight and cost of the restoration. An alternative to the traditional porcelain-metal FP is a hybrid restoration. This restoration design uses a smaller metal framework, with denture teeth and acrylic to join these elements together. This restoration is less expensive to fabricate and is highly esthetic because of the premade denture teeth and acrylic pink soft tissue replacements. In addition, the intermediary acrylic between the denture teeth and framework may reduce the impact force of dynamic occlusal loads. The hybrid prosthesis is easier to repair in the case of porcelain fracture because the denture tooth may be replaced with less risk than adding porcelain to a traditional porcelain-metal restoration. However,

the fatigue of acrylic is greater than the traditional prosthesis; therefore, repair of the restoration is more commonly needed. The crown height space determination for a hybrid versus the traditional porcelain- metal restoration is 15 mm from the bone to the occlusal plane. (Misch, 2005).

When less than this dimension is available, a porcelain-to-metal restoration is suggested. When a greater crown height space is present, a hybrid restoration is often fabricated. Implants placed too facial or lingual or in embrasures are easier to restore when vertical bone has been lost and an FP-2 or FP-3 prosthesis is fabricated because the greater crown heights allow the correction of incisal edge positions, and even extremely high smile lip lines do not expose the implant abutments. However, the FP-2 or FP-3 restoration has greater crown height compared with the FP-1 fixed types of prostheses; therefore, a greater moment of force is placed on the implant cervical regions, especially during lateral forces (e.g., mandibular excursions or with cantilevered restorations). As a result, additional implant abutments or shorter cantilever lengths should be considered with these restorations. An FP-2 or FP-3 prosthesis rarely has the patient's interdental papillae or ideal soft tissue contours around the emergence of the abutments because these restorations are used when there is more crown height space and the lip does not expose the soft tissue regions of the patient. In the maxillary arch, wide open embrasures between the implants may cause food impaction or speech problems. These complications may be solved by using a removable soft tissue replacement device or making over-contoured cervical restorations. The maxillary FP-2 or the FP-3 prosthesis is often extended or juxtaposed to the maxillary soft tissue so that speech is not impaired. Hygiene is more difficult to control, although access next to each implant abutment is

provided. The mandibular FP-2 and FP-3 restorations may be left above the tissue, similar to a sanitary pontic. This facilitates oral hygiene in the mandible, especially when the implant per-mucosal site is level with the floor of the mouth and the depth of the vestibule. However, if the space below the restoration is too great, the lower lip may lack support in the labio- mental region (Figure 24). (Misch, 1990).

Consideration	Porcelain	Hybrid Metal
Occlusal vertical	≤15 mm	≥15 mm dimension
Technique	Same	Same
Retention	Cement or screw	Cement or screw
Precision of fit	Same	Same
Esthetics	Same	Same
Soft tissue	Difficult	Easier
Teeth	Difficult	Easier (pre-made)
Time or appointments	Same	Less
Weight	More	Less
Cost	More	Less
Impact forces	More	Less
Volume (bulk)	Same	Same
Long term	Same	Same
Occlusion	Same	Same
Speech	Same	Same
Hygiene	Same	Same
Complications	Same	Same
Aging of materials	Less	More

Figure 1.22 Comparison of Porcelain-to-Metal versus Hybrid Protheses (FP-3) (Misch, 1990)

1.6.2. Removable Protheses

There are two types of RPs based on support, retention, and stability of the restoration. (Misch, 1990).

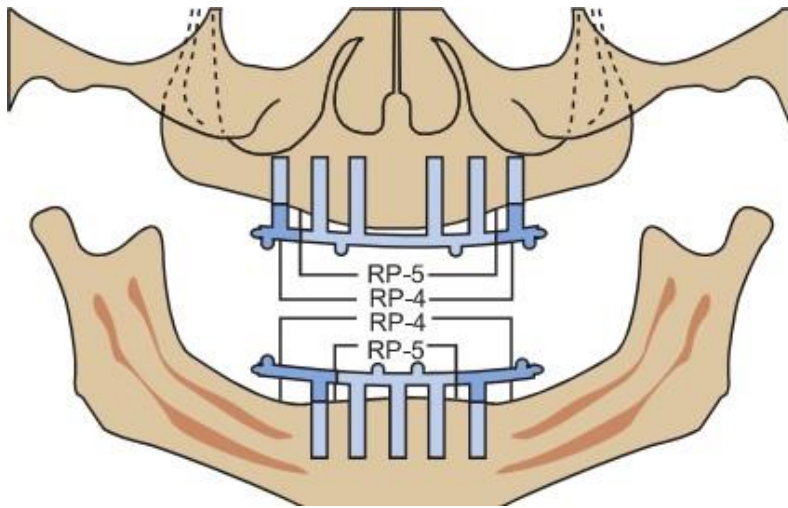


Figure 1.23 Removable restorations have two categories based on implant support. RP-4 prostheses have complete implant support in both the anterior and posterior regions. In the mandible, the superstructure bar often is cantilevered from implants positioned between the foramina. The maxillary RP-4 prosthesis usually has more implants and no cantilever. An RP-5 restoration has primarily anterior implant support and posterior soft tissue support in the maxilla or mandible. Often fewer implants are required, and bone grafting is less indicated. (Misch, 1990)

Patients are able to remove the restoration but not the implant-supported superstructure attached to the abutments. The difference in the two categories of removable restorations is not in appearance (as it is in the fixed categories). Instead, the two removable categories are primarily determined by the amount of implant support. The most common removable implant prostheses are over-dentures for completely edentulous patients.

Traditional removable partial dentures with clasps on implant abutment crowns have not been reported in the literature with any frequency. No long-term studies are currently available. On the other hand, complete removable overdentures have often been reported with predictability for many decades. (Naert et al, 1991)(Spiekermann et al, 1995)(Chan et al, 1995)(Johns et al, 1992)(Zarb et al, 1996).

As a result, the removable prosthetic options are primarily overdentures for the completely edentulous patient.

1.6.2.1. RP-4

RP-4 is an RP completely supported by the implants, teeth, or both.” The restoration is rigid when inserted: overdenture attachments usually connect the RP to a low-profile tissue bar or superstructure that splints the implant abutments. Usually, five to seven implants in the mandible and six to eight implants in the maxilla are required to fabricate completely implant- supported RP-4 prostheses in patients with favorable dental criteria (Figure 26). (Misch, 1991)

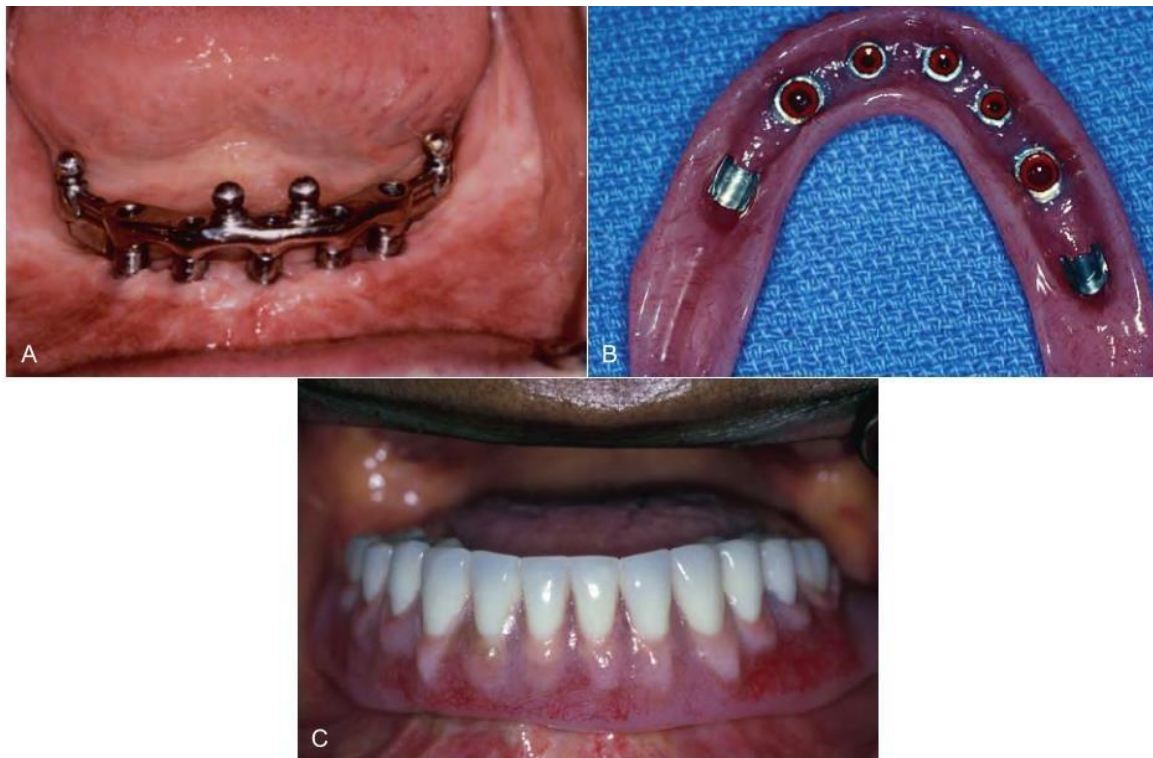


Figure 1.24 A, An RP-4 restoration is a removable prosthesis (usually an overdenture) that is completely implant supported. In this patient, the mandibular restoration has five implants between the mental foramina and a cantilevered bar to the posterior regions. The prosthesis is rigid during function and therefore requires attention to implant position and an implant number similar to an FP-3 restoration. B, The mandibular overdenture for an RP-4 prosthesis has attachments that permit a rigid restoration during function. C, An intraoral view of an RP-4 prosthesis appears as a mandibular denture but is rigid during function. (Misch, 1991)

The implant placement criteria for an RP-4 prosthesis is different than that for an FP. Denture teeth and acrylic require more prosthetic space for the removable restoration. In addition, a superstructure and overdenture attachments must often be added to the implant abutments. This requires a more lingual and apical implant placement compared with the implant position for an FP. The implants in an RP-4 prosthesis (and an FP-2 or FP-3 restoration) should be placed in the mesiodistal position for the best biomechanical and hygienic situation. On occasion, the position of an attachment on the superstructure or prosthesis may also affect the amount of spacing between the implants. For example, a Hader clip requires the mesiodistal implant spacing to be greater than 6 mm from edge to edge and as a consequence reduces the number of implants that may be placed between the mental foramina. The RP-4 prosthesis may have the same appearance as an FP-1, FP-2, or FP-3 restoration. A porcelain-to-metal prosthesis with attachments in selected abutment crowns can be fabricated for patients with the cosmetic desire of an FP. The overdenture attachments permit improved oral hygiene or allow the patient to sleep without the excess forces of nocturnal bruxism on the prosthesis. (Misch, 1991)

1.6.2.2. RP-5

RP-5 is an RP combining implant and soft tissue support. The amount of implant support is variable. A completely edentulous mandibular overdenture may have (1) two of three anterior implants independent of each other primarily for retention; (2) splinted implants in the canine regions to enhance retention and stability, (3) three splinted implants in the premolar and central incisor areas to provide improved

retention and lateral stability; or (4) four or five implants splinted with a cantilevered bar to improve retention, stability, and support which reduces soft tissue abrasions and limits the amount of soft tissue coverage needed for prosthesis support. The primary advantage of an RP-5 restoration is the reduced cost because fewer implants may be inserted compared with a fixed restoration and there is less demand for bone augmentation, often required for additional implants. The prosthesis is very similar to traditional overdentures supported by natural teeth. (Misch,2005).



Figure 1.25 Intraoral view of three mandibular implants inserted between the foramina. A bar connects the implants and can support an RP-5 mandibular overdenture, Soft tissue support of the restoration is required in the posterior regions because the implant position and number are not conducive to a completely implant-supported prosthesis. (Misch, 2005)

A preimplant treatment denture may be fabricated to evaluate to occlusal vertical dimension or ensure the patient's esthetic satisfaction. (Misch, 2005).

This technique is especially indicated for patients with demanding needs and desires regarding the final esthetic result or with severely reduced vertical dimensions with their present prosthesis. The implant dentist can also use the treatment denture as a guide for implant placement. The patient can also wear the treatment prosthesis during the healing stage. After the implants are uncovered, the superstructure is fabricated within the guidelines of the existing treatment restoration. After this is achieved, the preimplant treatment prosthesis may be converted to the RP-4 or RP-5 restoration. The clinician and the patient should realize that the bone will continue to resorb in the softtissue-borne regions of the prosthesis. Relines and occlusal adjustments every few years are common maintenance requirements of an RP-5 restoration. Bone resorption in the posterior regions with RP-5 restorations may occur two to three times faster than the resorption found with full dentures. (Jacobs et al, 1992).

Chapter Two: Conclusion and Suggestions

In traditional dentistry, the restoration reflects the existing condition of the patient. Existing natural abutments are first evaluated, and a removable or fixed restoration is fabricated accordingly. Implant dentistry is unique because additional foundation units may be created for a desired prosthodontic result. Therefore, both the psychological and anatomical needs and desires of the patient should be determined. The prosthesis that satisfies these goals and eliminates the existing problems may then be designed.

Whereas the prosthesis may be fixed or removable for completely edentulous patients, fixed restorations are planned for most partially edentulous patients.

If only one implant approach is used for all patients, the same surgical and prosthetic situations and flaws are invariably repeated. For example, if a two- or three-implant insertion is used on all edentulous mandibles, not only are the implant and surgery similar regardless of intraoral or extraoral conditions, but an RP-5 prosthesis will also usually result despite the patient's needs and desires.

The benefits of implant dentistry can be realized only when the prosthesis is first discussed and determined. An organized treatment approach based on the prosthesis permits predictable therapy results. 5 prosthetic options are available in implant dentistry. 3 restorations are fixed and vary in the amount of hard and soft tissue replaced; 2 are removable and are based on the amount of support for the restoration.

The amount of support required for an implant prosthesis should initially be designed similar to traditional tooth-supported restorations. After the intended prosthesis is designed, the implants and treatment surrounding this specific result can be established. For example, an FP-1 prosthesis, when desired, may have a narrow implant inserted rather than an osteoplasty and a larger diameter implant. As a general rule, an FP-3 restoration requires more implant support than an FP-1 restoration whenever a cantilever or lateral load is applied because the crown height space is greater. Hence, the prosthetic option is one of the first factors to determine the overall implant treatment plan.

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