



Navigating The Factors Affecting Implant-Supported Prosthetic Decisions: A Narrative Review

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Introduction

Modern day implant dentistry is prosthetically driven i.e. the implant number and location is decided by the type of prosthesis to be delivered to the patient. From single-tooth implants to full-arch restorations, a wide range of implant-supported prosthetic options cater to diverse patient needs. Implant supported prosthesis provide long lasting and natural looking restorative options. Prosthetic rehabilitation helps to improve oral health, aesthetics and quality of life of the patients. The choice of prosthesis for any given patient depends on various factors such as the prosthetic space/crown height space available, the amount and quality of bone, the location and length of edentulous area, the support taken from the surrounding bone, etc.

The purpose of this article is to provide comprehensive review of factors influencing implant supported prosthesis. Application of these factors in clinical practice leads to long term success of the prosthesis and also helps clinicians in evidence based decision making. Factors determining implant supported prosthetic options include:

1. Crown- Height space (CHS)
2. Amount of bone available
3. Location and span of edentulous area
4. Opposing arch
5. Esthetic consideration
6. Age
7. Cost

These factors will be discussed in detail in the following sections.

Factors affecting prosthetic options:

1. Crown-Height Space (CHS)

CHS or the prosthetic space available is the primary factor for choosing prosthesis type.

A. Misch (2008) [1] divided prosthetic options into 5 broad types depending on the crown height space or the on the resorption of the alveolar bone.

Type of prosthesis	Description	
FP-1	Fixed prosthesis Minimal bone resorption, only crown portion is replaced.	
FP-2	Fixed prosthesis Bone resorption is more such that a portion of the root has to be replaced and the crown appears elongated in the gingival half.	
FP-3	Fixed prosthesis Bone resorption is even more extensive such that a significant portion of bone has to be replaced. Pink colored acrylic or porcelain has to be added to the prosthesis.	
RP-4	Removable prosthesis Implant supported overdenture	
RP-5	Removable prosthesis Implant and soft tissue supported overdenture	

B. Ali Tunkiwala (2017) [2] proposed a numerical classification/guideline to help in the selection of treatment option according to the interarch distance available for the prosthesis. He proposed 4 main categories:

- Interarch space 10 – 12 mm
- Interarch space 12 – 15mm

- Interarch space 15 -18 mm
- Interarch space >18mm

2. Bone

Amount and quality of bone available determines the location, type and number of implants placed for a particular patient.

A. Misch(2008) [1] proposed a classification depending on the quality and quantity of bone. He divided bone into four divisions that is Division A, Division B, Division C and Division D. (Fig 2.1)

Division of bone	Division A	Division B	Division C	Division D
Width	>6mm	2.5-6mm B+=4-6mm B-w=2.5-4mm	C-w=0-2.5mm	Severe atrophy Flat maxilla Pencil thin mandible
Height	>12mm Mesio-distal (MD) - >7mm	>12mm MD->6mm	C-h= <12mm	Basal bone loss
Angulation of occlusal load	<30 degrees	<20degrees	C-a = >30 degrees	-
Crown Height Space (CHS)	<=15mm	<15mm	>15mm	>20mm
Treatment options	<ul style="list-style-type: none"> • FP1 • FP2 • FP3 • Depending on the number of missing teeth and the lip line of the patient (osteoplasty may be required) • RP4 • RP5 • CHS is less hence osteoplasty may be required. 	<ul style="list-style-type: none"> • Narrow diameter implant Modify with osteoplasty and convert to Div A: • FP2/3 if height is>12mm • RP4/5 if adequate CHS Converts to C-h if height <12mm • Augmentation to convert to Div A- FP1 • Expand Div B to Div A with bone spreaders 	<ul style="list-style-type: none"> Osteoplasty (C-w) • Root form implants (C-h) • Subperiosteal implant (C-h, C-a partial, or completely edentulous mandible) • Augmentation procedures before implant insertion • Disk design implants (posterior mandible, anteriormaxilla) • Ramus frame implant (C-h completely edentulousmandible) • Transosteal implant (C-h anterior mandible) 	<ul style="list-style-type: none"> • Fixed restorations contraindicated • Autogenous iliac crest graft if implants are to be placed. • RP5-in anterior implants • If only posterior maxilla is Div. D - sinus graft procedures

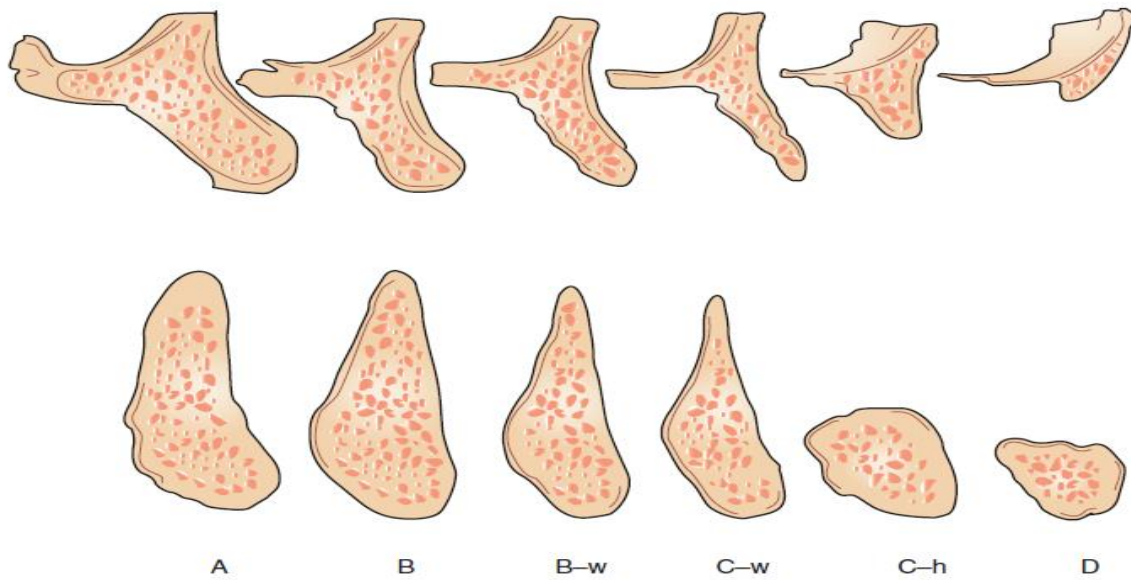
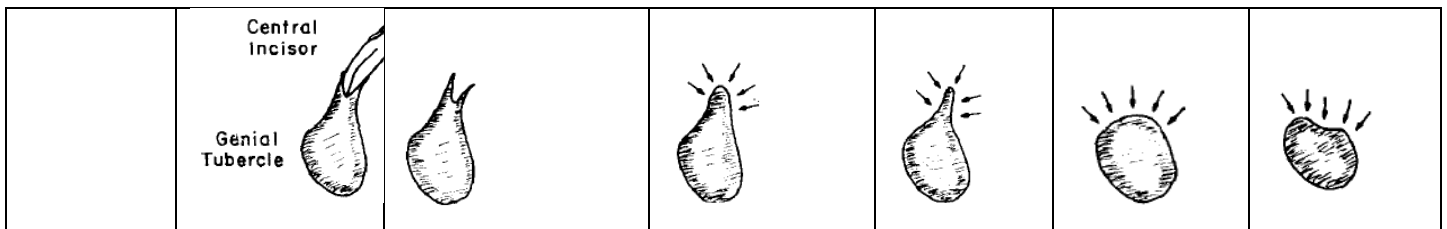


Fig. 1: Different divisions of bone

Source: Misch CE. Dental implant prosthetics. 2nd ed. Amsterdam, Netherland: Elsevier Health Sciences; 2015.

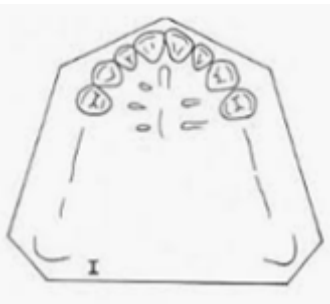


B. Atwood (1971) [3] proposed a classification of the residual bone after extraction of teeth and divided them into six orders depending on the bone resorption following extraction.

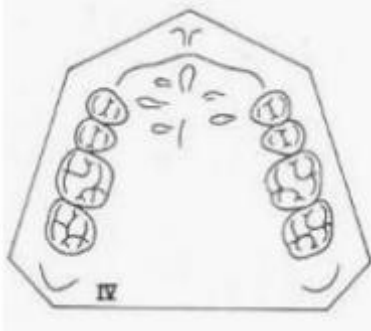



Order	Order I	Order II	Order III	Order IV	Order V	Order VI
Feature	Pre extraction	Post extraction	High, well rounded	Knife edge	Low, well rounded	Depressed
Prosthetic option		Immediate implant placement	FP 1 FP 2 FP 3 prosthesis depending on the esthetic requirement and number of missing teeth. Other options same as Division A	Options same as Division B-w	Options same as Division C-h	Options same as Division D


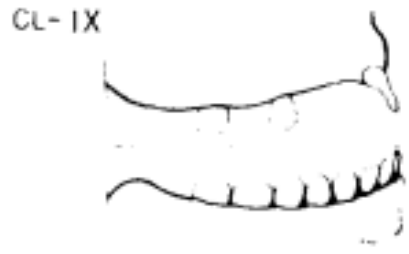



3. Location and Span of Edentulous Area

The next factor in determining the prosthetic option is the location and span of edentulous area. Kennedy (1923)[4] gave the most widely accepted classification for the partially edentulous spans.

Class	Description	Prosthetic options	
Class I	Bilateral edentulous areas located posterior to the remaining natural teeth	The prosthetic options depend on the division of bone in the edentulous area. If bone quantity is good, one implant for each missing tooth recommended while for narrow ridge cases, splinting is usually required. Implant supported removable prosthesis can also be given.	
Class II	Unilateral edentulous areas located posterior to the remaining natural teeth	The options are same as for class I arches but fixed prosthesis is preferred as compared to removable options.	
Class III	Unilateral edentulous area with natural teeth both anterior and posterior to it	Implant number and type of prosthesis depend on the span of the edentulous area. Implant supported fixed prosthesis is usually recommended however removable options can also be considered.	

Class IV	Single, bilateral edentulous area located anterior to the remaining natural teeth	Restoring the esthetics is the prime requirement in class IV cases. The prosthetic options depend on lip support and on the amount of bone available. Hence can be FP1, FP2, FP3 while removable options can also be considered.	
Class V	Unilateral edentulous area with natural teeth both anterior and posterior to it with anterior abutment not capable of providing support	The options are similar to class III cases. Implant tooth supported removable restoration can also be considered.	
Class VI	Unilateral edentulous area with natural teeth both anterior and posterior to it with anterior abutment capable of providing support	The options are similar to class III cases however Fixed options are usually recommended.	
Class VII	All the remaining teeth are present at one side of the arch (not crossing the midline) such that the fulcrum line would be compatible with the physiologic forces.	The edentulous span is extensive. Implant supported fixed as well as removable restoration can be given. If remaining teeth are few, they can be reduced to overdenture copings and tooth- implant supported overdenture can be given.	
Class VIII	1 -2 or maybe 3 teeth are located at either anterior corner of the arch such that the	Teeth can be reduced to overdenture copings to be used for tooth-implant supported overdenture. However fixed implant supported prosthetic (ISP)	

	fulcrum line would be incompatible with the action of physiologic forces.	options can be considered if the ridge quality and quantity is favourable.	
Class IX	The edentulous area is such that the functional and cosmetic requirement and the magnitude of interocclusal distance require the use of telescopic prosthesis as the remaining teeth are capable of partial or complete support	Tooth-implant supported overdenture is the most favourable option however the remaining teeth can be submerged and implant supported fixed restoration can be considered.	
Class X	The remaining teeth are incapable of any support. If teeth are retained the prosthesis is completely tissue borne.	The best treatment is to submerge the teeth with poor prognosis followed by implant supported fixed or removable prosthesis.	

4. Opposing Arch[5]

It is important to evaluate the force from opposing arch while planning the prosthetic rehabilitation and occlusal scheme for a patient.

Opposing arch can be: fully edentulous, fully dentulous and partially dentulous.

For simplification of understanding, we will be discussing the options for mandibular arch while considering maxilla as the opposing arch with these 3 modalities. Discussing each option with respect to the type of prosthesis and the occlusal scheme:

Fully edentulous opposing arch (restored with conventional complete denture)

- In such cases, to balance the force factors, the mandibular arch should be restored with either a conventional complete denture or implant-mucosa supported overdenture (RP5 prosthesis).
- Bar and clip supported overdenture can be used.
- Implant supported fixed prosthesis and implant supported overdenture is best avoided as it will lead to excessive forces on the maxillary ridge and can lead to bone resorption or combination syndrome.

- Bilateral balanced occlusion is the preferred occlusal scheme.

Fully dentulous opposing arch

- Implant supported fixed prosthesis is the treatment of choice. A minimum of 4 implants should be used to give a full arch implant supported fixed restoration.
- To minimize leverage forces on the implant, cantilever extension should be kept as small as possible.
- If the interocclusal distance, esthetics and financial conditions of the patient precludes the use of fixed restoration, implant supported overdenture (RP-4) is the treatment of choice.
- Group function or a mutually protected occlusal scheme should be planned.

Partially edentulous opposing arch

- The treatment modality changes depending on location and extent of edentulous span.
- **For a Kennedy Class 1 situation**, if the edentulous span is long and is restored with a removable prosthesis, mandibular arch should be restored with a conventional complete denture or implant-mucosa supported removable prosthesis (RP 5) to balance the masticatory forces. Bilateral balanced occlusion is the preferred scheme.
- However, if a fixed restoration is planned for the maxillary arch or if the edentulous span is short, the mandibular arch should be restored similar to when the opposing arch is fully dentulous. Group function or a mutually protected occlusal scheme should be planned.
- **For Kennedy Class II situation**, restored with a removable prosthesis, implant-mucosa supported overdenture (RP 5) is preferred with bilateral

balanced occlusion however if the span is short of if restored with fixed restoration, implant supported fixed prosthesis is preferred while implant supported overdenture can also be used and group function or a mutually protected occlusal scheme is planned.

- **For Kennedy Class III/IV situation**, implant supported fixed restoration and implant supported overdenture are the preferred treatment options depending on whether the opposing arch is restored with a fixed or removable restoration respectively. Group function or a mutually protected occlusal scheme should be planned.

Esthetics

Apart from bone availability, prosthetic space and occlusal consideration, esthetic requirements of each patient need to be taken into account before deciding upon the treatment option. The anterior ridge morphology and cosmetic display also influence the treatment outcome.

A. Cosmetic display – it is the first factor that affects the choice of prosthesis in the anterior region. The lip length, lip tonicity and the smile line are the factors that affect cosmetic display.

Tjan (1984)[6] gave the classification of smile depending on the display of maxillary anterior teeth. 3 basic smile types are:

- High smile (S1) – Display of the whole cervicoincisal length of maxillary anterior teeth including the band of gingiva.
- Average smile (S2) – Display of 75-100% of maxillary anterior teeth and interproximal gingiva.
- Low smile (S3) – Display of less than 75% of maxillary anterior teeth.

Ali Tunkiwala (2019)[7] categorized the lip line depending on the amount of cosmetic display:

- C1 - Low Lip Line (less than 75% of anterior teeth displayed)
- C2 - Medium Lip Line (75%-100% of anterior teeth and interproximal gingiva displayed)
- C3 - High Lip Line (Complete anterior teeth and continuous band of gingiva).

B. Ridge contour—the next factor that plays a role in esthetics is the ridge contour. The width, height and contour of the ridge affects the design of the prosthesis and hence the prosthetic option.

- Overcontoured ridge –Crestotomy is required to recontour the ridge and FP 1 type of prosthesis is chosen.
- Deficient bone height – restoration of esthetics is very critical in such cases. Ridge augmentation should be considered however if it is not possible, FP2, FP3 type of prosthesis should be used. FP 1 prosthesis is best avoided while overdentures can be used to provide sufficient ridge support.
- Deficient width –this affects the labial contour and hence the esthetics of the patient. Augmentation should be considered however if not possible, FP3 prosthesis and overdenture is the treatment of choice.

C. Age [7]

Other factors being constant, prosthetic options are not the same for patients with different age groups.

- A younger patient is usually more concerned about the esthetic outcome while an older patient demands better function.
- A prosthesis will have to work longer in a young patient as compared to a patient an old patient.
- The masticatory forces are also high in a young patient as compared to an older patient. Hence a

fixed prosthesis is preferred for a young patient to better dissipate the forces of mastication.

- An older patient having deficient bone may not be able to handle the morbidity of augmentation procedures as well as the patient of younger age group can, hence overdentures are the treatment of choice in older people while fixed prosthesis following augmentation is the choice in younger patients.

D. Cost

In addition to clinical factors, socioeconomic status of the patient plays deciding role in classifying the prosthetic options.

- A person who is socioeconomically sound can afford any treatment hence a treatment requiring more implants can be chosen for such a patient for a poorer patient, an alternative prosthesis involving less implants or even a simple removable prosthesis may have to be chosen.
- The type of superstructure also affects the cost of the treatment. Paulo-malo type hybrid prosthesis involves the use of titanium framework hence increasing the cost. Zirconia framework is also more expensive when compared to cast framework.
- Zirconia abutment and all ceramic crowns are also more expensive.
- Multiunit abutments are more expensive when compared to standard abutments.
- PEEK/ BioHPP are the new materials for use in implant dentistry with excellent biocompatibility and low force factors however they also increase the cost of the treatment.

Treatment cost needs to be compatible with the patients financial affordability.

Classification systems available in literature

Depending on these factors, various authors have proposed various classification systems that help in the treatment planning and choice of prosthesis for the patients.

1. American College of Prosthodontists (ACP) (2002)[8]

ACP devised a classification for the completely edentulous patients based on 4 diagnostic criteria - The residual ridge height, ridge morphology, maxillomandibular relationship and the location of muscle attachment.

Depending on these factors, they classified the completely edentulous arches into 4 classes as follows:

Class I – The edentulous ridges that fall under this class have the most ideal condition and favourable diagnostic criteria and can be treated with conventional complete dentures.

- Residual bone height is ≥ 21 mm measured at the least vertical dimension on a panoramic radiograph
- Ridge morphology is favourable and resists any vertical or horizontal movement of denture base; type A maxilla
- Location of muscle attachment is favourable for denture stability and retention; type A or B mandible
- Maxillomandibular relationship is class 1 type.

Class II - There is continued degradation of the denture supporting area. There is specific patient management and early onset of systemic disease interactions.

- Residual bone height is 16 – 20mm
- Ridge morphology is favourable and resists any vertical or horizontal movement of denture base; type A or B maxilla

- Location of muscle attachment has some influence on denture stability and retention; type A or B mandible
- Maxillomandibular relationship is class 1 type
- Mild systemic disease with oral manifestation, psychological considerations and minor modification has to be done

Class III – There is a need for surgical interventions for adequate prosthodontics function. Treatment outcome is affected by additional factors

- Residual bone height is 11-15mm
- Ridge morphology minimally resists any vertical or horizontal movement of denture base; type C maxilla
- Location of muscle attachment moderately influence denture stability and retention; type C mandible.
- Maxillomandibular relationship may be class I,II or III
- Need for minor soft tissue and hard tissue procedures although implant placement doesn't require augmentation and the interarch space available is 18-20mm
- Other findings include: TMD symptoms, moderate psychological considerations, oral manifestations of systemic diseases, large tongue, hyperactive gag reflex

Class IV – Edentulous area is most debilitated in this class. Patient's health, preferences, past dental history, and financial considerations preclude the surgical interventions which are otherwise almost always required. Special prosthodontics techniques are required for an adequate outcome.

- Residual bone height is 10mm
- Maxillomandibular relationship may be class I,II or III, maxillomandibular ataxia (incoordination)

- Ridge morphology does not resist vertical or horizontal movement of denture base; (type D maxilla)
- Location of muscle attachment significantly influence denture stability and retention; (type D or E mandible).
- Pre prosthetic surgery, augmentation before implant placement, hard tissue augmentation and soft tissue revision required, correction of insufficient interarch space, severe oral manifestation of systemic disease and professional intervention for psychosocial conditions are often required

This was more of a subjective classification with esthetic limitations.

2. Implant – Prosthodontic Classification for Fixed Rehabilitation (2014)[9]

Proposed by **Dimitrios Papadimitriou**, this classification was based on requirement of horizontal augmentation and location and number of implant based on the degree of bone available.

Depending on requirement of horizontal augmentation two types were suggested:

Type A – horizontal augmentation not required such that after implant placement, 1mm of bone is available on both buccal and lingual aspect.

Type B - horizontal augmentation is required such that after implant placement, less than 1mm of bone is available on both buccal and lingual aspect.

Based on the number and location of implant placement, the arches are divided into 4 categories:

- C1 – implants would be placed such that a fixed prosthesis from 1st molar to 1st molar is made. The prosthesis may be as a single unit or segmented
- C2 – implants would be placed such that a fixed prosthesis from 1st molar to 1st molar with a

unilateral cantilever is made. The prosthesis may be as a single unit or segmented.

- C3 - implants would be placed such that a fixed prosthesis that is short arch (till 2nd premolar) with a bilateral cantilever is made. The prosthesis may be as a single unit or segmented.
- C4 – here only a removable prosthesis can be planned. Overdenture can be used in mandible but not in maxilla.

This classification didn't take into account the vertical dimensions of the ridge and the type of prosthesis that could be used.

3. Classification system for selection of number of implants and superstructure selection on the basis of available vertical restorative space (AVRS) and interforaminal distance (IFD) for implant supported mandibular overdenture (2015)[10]

Proposed by **Akshay Bhargava**, this classification was aimed at describing the appropriate implant number, implant location (right first premolar to left first premolar (A, B, C, D, E) (Fig 2.2) and the type of attached to be used for overdenture depending on the available vertical restorative space and the interforaminal distance.



Fig. 3: A,B,C,D,E positions in mandible

Source : Misch CE. Dental implant prosthetics. 2nd ed. Amsterdam, Netherland: Elsevier Health Sciences; 2015.

Class		AVRS	IFD	No. of implants and location of implant	Attachments that can be used
I	a	≥14 mm	≥40 mm	5 or less implants A,B,C,D,E positions	Bar, locator and bar and clip attachments
	b	≥14 mm	30-40 mm	4 implants A,B,D,E positions	Bar, locator and bar and clip attachments
II	a	8-14 mm	≥30 mm	4 implants A,B,D,E positions	Bar, locator attachments
	b	8-14 mm	≤30 mm	2 implants B,D positions	Bar, dalla-bona attachments
III	a	6 - 8 mm	≥30 mm	4 implants A,B,D,E positions	Bar, locator attachments
	b	6 - 8 mm	<30 mm	2 implants B,D positions	Locator attachments

4. Lip – Tooth – Ridge classification (2017)[11]

Adrien Pollini, proposed a classification to plan the treatment and identify the prosthetic option for edentulous maxilla. It is based on the position and dynamics of the lip, position and dimension of the maxillary central incisor, the ridge architecture and prosthetic space available.

Class 1 – The distance between the proposed incisal edge and the alveolar ridge is adequate and depending on the lip tonicity, it is further divided into LER (Low Esthetic Risk) i.e when the exaggerated smile line only exposes the interdental papilla and the HER (High Esthetic Risk) i.e when the exaggerated smile line exposed a significant part of the alveolar mucosa. Minimum bone loss hence convention crown and bridge implant supported prosthesis can be used. Connector size should be adequate.

Class 2 – There is larger vertical space between the proposed incisal edge and the alveolar ridge hence pink acrylic may have to be added for optimum esthetics. It is also divided into LER and HER depending on the lip tonicity. HER category requires that the junction of

prosthesis and alveolar ridge needs to be hidden under the lip on exaggerated smile.

Class 3 – Primarily includes horizontal tissue deficiency however vertical deficiency may also be there, leading to inadequate lip support necessitating a labial flange. Overdentures are the treatment of choice that is telescope retained.

Class 4 – Includes significant loss of vertical and horizontal component of bone which necessitates the use of a removable prosthesis with a labial flange hence bar retained overdenture is the best option. Fixed prosthesis usually avoided as it presents with increased biologic complications.

5. “ABCD” Implant Classification (2019)[7]

Dr Ali Tunkiwala proposed a classification based on 4 vital parameters of Age, Bone volume, Cosmetic display and Degree of resorption. Each category was further divided into four subtypes which then helped in the selection of final restoration for the patient and helps the clinician to precisely understand the number and type of implant and the need for regenerative procedures required for the patient.

A (age): Treatment need for young and old population varies so the same treatment plan cannot be applied for both. Accordingly, they have been categorized as:

- A1- Young edentulous (<50 years)
- A2- Intermediate edentulous (50-65 years)
- A3- Old edentulous (65-75 years)
- A4- Geriatric edentulous (>75 years)

B (bone): it is further classified based on the availability of bone into:

- B1 = Bone available in all zones; 6 to 8 axial implants without cantilever can be placed
- B2 = Bone available in only incisors & bicuspid region; 2 to 4 axial implants can be placed in the incisor region with two tilted implants in the bicuspid region.
- B3 = Bone available in Incisors and zygoma; 2 to 4 implants in the incisor region with tilted implants in the zygoma on each side.
- B4 = Bone available in only zygoma (quad); 2 implants in zygoma (quad zygoma) on each side can be placed.

C (cosmetic display): The type of prosthesis and the resultant aesthetics is also affected by the position of the lips and their muscle tone. Hence, depending on the lip line and visibility of anterior teeth, it is divided into:

- C1= Low Lip Line (less than 75% of anterior teeth displayed)
- Type of prosthesis is not much of a concern in such patients as only the incisal and middle third of the crown is visible on maximum smile.

- C2 = Medium Lip Line (75%-100% of anterior teeth and interproximal gingiva visible)
- For patients with good bone support and properly contoured papilla, FP 1 type prosthesis can be planned however if bone loss is there or the papillary contour is lost because of multiple missing adjacent teeth, pink porcelain should ideally be added to avoid black triangles and resultant unesthetic appearance.
- C3 = High Lip Line (Complete anterior teeth and continuous band of gingiva visible). Here, crestotomy should be considered. If the interarch space is also less, metal ceramic prosthesis should be considered however if the interarch space is excessive, overdenture maybe be necessary to provide sufficient lip support.
- Replacement of the gingival esthetics is the major concern in such patients. The natural emergence profile of the tooth should be mimicked as far as possible.
- If the interarch space is less, metal ceramic prosthesis should be considered however if the interarch space is excessive, overdenture maybe be necessary to provide sufficient lip support.

D (degree of resorption): Also known as **the numerical classification(2017)[2]** for the selection of implant supported prosthesis

Depending on the availability of interarch space, the prosthetic option and the material to be used is also varied. Based on this, it is divided into:

Category	Inter-arch space	Amount of restoration required	Fixed prosthetic option	Removable prosthetic option	Prosthetic material
D1 (Minimal)	10-12mm	Only the crown portion	Screw or cement retained crown	Contraindicated	PFM, monolith or layered zirconia

D2 (Moderate)	12-15mm	Crown and portion of gingiva	Screw or cement retained crown with pink ceramic to mimic gingiva	Overdentures with locator or telescopic crown	PFM, monolith or layered zirconia,
D3 (Moderate)	15-18mm	Alveolar bone loss has to be restored	Hybrid prosthesis	Overdentures with ball, locator or telescopic attachments, low profile milled bars	Metal framework with acrylic crown or Bio HPP framework with composite resin crown or Combination Bridge using screw retained milled framework
D4 (Excessive)	>18mm	Excessive hard and soft tissue lost	Contraindicated	Overdentures with milled or casted bar attachments or telescopes	Milled or casted bar

These factors should be carefully identified and listed at the diagnostic stage and before forming definitive treatment plan for the patient. For example: a young patient (A1) with sufficient bone available (B2), high lip line (C3) and some resorption of bone (D2), the treatment plans would be different than for an older individual (A4) with the same parameters. The prosthesis that would last long and is of a fixed type would be required for the young patient also a young patient would be able to tolerate any surgical procedure, like crestotomy, bone augmentation, better.

Conclusion

Dental implants have become the gold standard for prosthetic rehabilitation. Choosing the appropriate implant-supported prosthetic options plays a critical role in ensuring the success of dental rehabilitation. This decision making is influenced by a variety of factors such as the amount of bone available, age, esthetic expectation, financial considerations, etc. Selecting the appropriate prosthetic option requires a careful balance of clinical expertise and patient centered care. The

current paper discusses these factors in detail that can help the clinicians to tailor treatment plans according to each patient for optimal esthetic and functional outcomes. A thorough diagnostic process, combined with clear communication about benefit and limitation of available options would help not only the clinicians but also the patients into decision making for a good prosthetic outcome.

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