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Review Article

Implant Selection Criteria in Maxillary Defects: A Review

Canan AKAY[1]* and Sadeq Mohammed Taqi FADHIL[2]

[1]*Associate Professor, Department of Prosthodontics, Eskisehir Osmangazi University, Turkey*

[2]*Research Assistant, Department of Prosthodontics, Eskisehir Osmangazi University, Turkey*

***Corresponding Author:** Canan AKAY, Associate Professor, Department of Prosthodontics, Eskisehir Osmangazi University, Turkey.

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Abstract

Reconstruction of maxillary bone defects due to pathological or congenital causes is one of the most challenging areas of oral and maxillofacial reconstruction. The main purpose of these reconstructive efforts is to protect and improve the patient's quality of life by trying to restore the lost form and function. Surgical methods are applied primarily for the closure of the defect, but in cases where surgical obturation is inadequate or not applied, prosthetic rehabilitation of defect is required. It is very difficult to maintain retention in prostheses made to patients with maxillary resection. In patients with maxillary defect, and in patients with excessive resorption, it is almost impossible to achieve retention with the conventional prosthesis. The development of osseointegrated dental implants and their use in patients with the maxillary defect has been very useful. Implants have increased stability and implant treatment has become the current treatment method. Dental implants can be used on both the defect and non-defect sides of the maxillary arch, the zygomatic bone around the defect with sufficient bone volume to place the implants can be placed in the processus frontalis, orbital bone, tuber maxilla and pterygoid region of the maxilla.

Keywords: Maxillectomy; Obturator; Implant; Implant Types; Treatment Planning

Introduction

The maxillary sinus is the largest of paranasal sinuses and most common malignant sinus tumor. 80% of paranasal sinus cancers occur in the antrum, 20% in the ethmoid sinus and less than 1% in the frontal and sphenoid sinus [1]. Reconstruction of maxillary bone defects due to pathological or congenital causes is one of the most challenging areas of oral and maxillofacial reconstruction. The main purpose of these reconstructive efforts is to protect and improve the patient's quality of life by trying to restore the lost form and function [2].

Surgical removal of maxilla or part of maxilla is defined as maxillary resection [3]. There are several classification systems used for grouping maxillectomy defects according to the classification of the maxillectomy defect area, tissue loss, and possible rehabilitation options. Brown., *et al* [4]. they show the classified maxillectomy defects according to the vertical and horizontal components (Figure 1). The vertical component (class 1-4) determines the extent of the one-sided participation, which emphasizes the presence of oronasal or oroantral fistulas separating class 1 and 2 and the degree of orbit involvement separating class 3 and 4. The horizontal dimension (a-c) describes the palate and the amount of sacrificed alveolar ridge. The vertical component tends to have a greater impact on the aesthetic result, while the horizontal component has a more significant functional result. Okay., *et al* [5]. developed a classification scheme (class 1-4) based on abutment forces around the abutment line between defect size and end of abutment teeth on which console ends are based (Figure 2). Aramany described a universally accepted classification system. According to this classification, maxillectomy has examined the defect regions in 6 sections (figure 3) [6].

- **Class 1:** The resection line passes through sutura palatina media. It is mostly encountered defect type. Also known as classical hemimaxillectomy. The upper half jaw and teeth are intact on the unresectable side.
- **Class 2**: It is the type of defect where the premaxilla and unilateral macros are protected without resection.
- **Class 3**: The resection covers the middle part of the hard palate. The alveolar crest is completely protected.
- **Class 4:** Pro machine was resected with the unilateral maxilla.

- **Class 5:** Only premaxilla was not resected, both maxilla were removed.
- **Class 6:** Only premaxilla was resected.

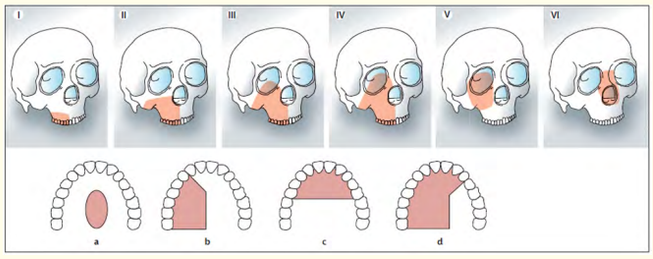

Figure 1: Classification of vertical and horizontal maxillectomy and midface defect.

Vertical classification: I—maxillectomy not causing an oronasal fistula; II—not involving the orbit; III—involving the orbital adnexae with orbital retention; IV—with orbital enucleation or exenteration; V—orbitomaxillary defect; VI—nasomaxillary defect. Horizontal classification: a—palatal defect only, not involving the dental alveolus; b—less than or equal to 1/2 unilateral; c—less than or equal to 1/2 bilateral or transverse anterior; d—greater than 1/2 maxillectomy. Letters refer to the increasing complexity of the dentoalveolar and palatal defect and qualify the vertical dimension.

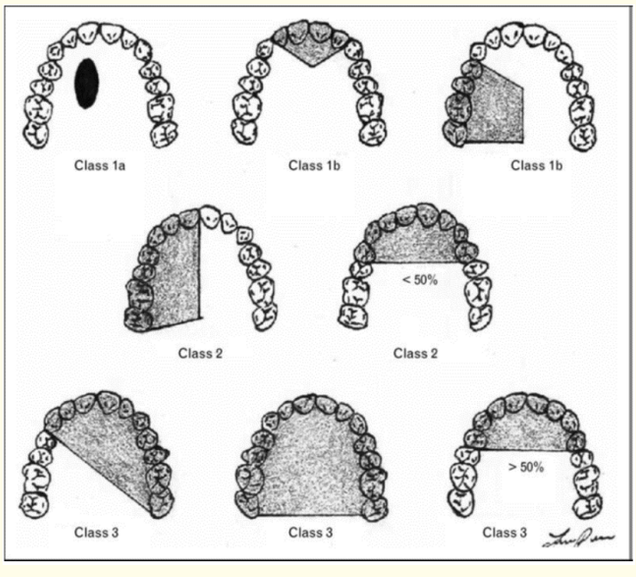

Figure 2: Maxillectomy classification scheme according to Okay., *et al.*

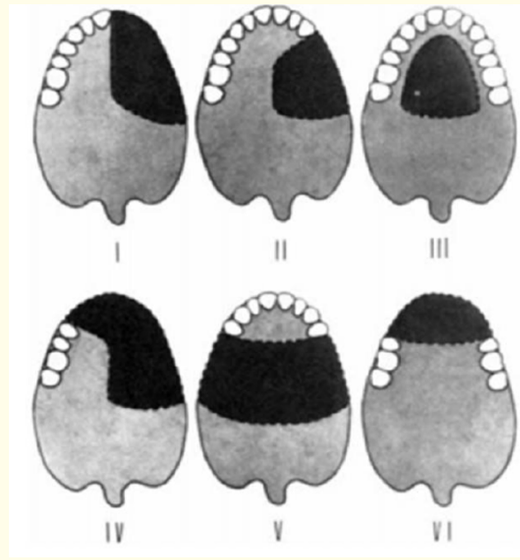

Figure 3: Aramany Partial maxillectomy classification. Class I, Midline resection. Class II, Single sided resection. Class III, Central resection. Class IV, Double-sided antero-posterior resection. Class V, Posterior resection. Class VI Anterior resection.

Piro., *et al.* described classification are popular among surgeons and maxillofacial surgeons. In this classification system, the degree of maxillary resection is defined. The limited maxillectomy is defined as any maxillary resection that primarily removes the wall of the antrum, usually floor or medial wall. Subtotal maxillectomy is defined as any maxillectomy without an anterior wall, which removes at least 2 walls including the antrum's floor (hard palate) [7].

Maxillary obturators and retention principles

Individuals with maxillary resection are faced with many problems of aesthetic, functional, psychological and social problems. Obturator corrects the patient's phonation, function, swallowing function and supports the orbital base. In addition, it improves the patient's psychosocial status and contributes to the aesthetics by correcting the cheek and lip contour [8]. These obturators are grouped into 3 main classes: Temporary surgical obturator prostheses, Therapeutic obturator prostheses, and permanent obturator prostheses. Retention is resistance to vertical displacement of prostheses. Retention in maxillary defects, structures that assist in the retention of obturator after the maxilla resection; maxilla, remaining teeth, alveolar crest and limits of the defect [9]. Degree of toothlessness is a critical factor in maintaining prosthesis retention. Teeth have a most important share in the retention of obturator prostheses. Beumer III., *et al.* the residual

soft palate in defect area, residual hard palate, anterior nasal patency, lateral scar band and height of the lateral wall provides retention [10].

It is very difficult to maintain retention in prostheses made to patients with maxillary resection. In patients with maxillary defect, and in patients with excessive resorption, it is almost impossible to achieve retention with a conventional prosthesis. The development of osseointegrated dental implants and their use in patients with the maxillary defect has been very useful. Implants have increased stability and implant treatment has become the current treatment method [11].

Implant use in maxillary defects

Endosseous implants are routinely used in many areas in clinical practice. Osseointegrated implants, the obturator can assist in the retention, stability, and support of prostheses, dental implants have distinct advantages in the treatment of jaw facial defects. Loss of soft and hard tissues often provides implant-protected delay times, which are necessary to adequately support lips and cheeks and restore oral functions [10]. Al-Salehi., *et al.* 2007 reported that excessive wear of implant was preferred treatment when severe soft and hard tissue deficiency was present [12]. Implant-supported prostheses are a good treatment alternative to provide aesthetic, structural and functional rehabilitation of patients with the maxillary defect. In most cases of maxillary resection, implant-assisted overdentures are more suitable than fixed prostheses and may even be the only treatment alternative. Most of these patients have less than 5 years of life and require effective and practical treatment [13]. The overall survival rate for implants supporting maxillofacial prosthesis was reported to be more than 95%. Dental implants can be used on both the defect and non-defect sides of the maxillary arch [14], the zygomatic bone around the defect with sufficient bone volume to place the implants can be placed in the processus frontalis, orbital bone, tuber maxilla and pterygoid region of the maxilla [3].

Implant regions in patients with maxilloful defect

Zygomatic bone

Small and quadrupolar zygoma bones; It has four protrusions, frontal-sphenoidal, orbital, maxillary and temporal and constitutes the most important support structure in the middle face. It is associated with sphenoid bone in lateral, frontal bone in superior, and with maxilla in medial and inferior. It forms a zygomatic arch with the temporal bone. Frontal bone and the parts that connect with the maxilla are the thickest and strongest places [15]. The zygoma bone can be compared to a pyramid offering interesting anatomy for implant placement. Proven strength of this anchor is in conflict with the low bone quality in the posterior maxilla. Due to this bone density, it is also used in the treatment of jaw-face fractures in the placement of jaw plates. It is also used during orthodontic treatment and offers a constant anchorage to ensure tooth movement [16]. In order to increase the retention of prostheses in maxilla atrophy and defects, zygoma bone is also used as an implant site. In 1989 a zygomatic fixture was developed to attach implants to zygomatic bone and to the maxillary alveolar bone. The zygomatic fixture is a transverse titanium implant that is inserted transversally to compact bone of zygomatic bone in palatal aspect of resected posterior maxilla [17].

Many studies reported that can be used a zygomatic bone as implant site, a simple, predictable and low-cost solution for reconstructing maxillary bone defects. Also, described anatomical features of zygoma bone for implant placement [18]. These studies showed that anteroposterior (AP) length of the zygomatic bone was 14.1 to 25.4 mm, and mediolateral (ML) thickness was between 7.6 and 9.5 mm [19]. In 1997, Weischer., *et al* [20]. emphasized the use of a zygoma bone as a supportive structure for prosthetic rehabilitation in patients undergoing maxillectomy.

Pterygoid region

The posterior region of maxillary bone has many limitations in the placement of dental implants such as poor bone quality and quantity. In addition, the posterior region of the maxilla is one of the most common clinical studies where implant placement can be difficult [21]. Several techniques have been described for placement of implants in the posterior atrophic maxilla. Short implants and sinus lifting procedures are most commonly used [22]. An alternative procedure is to place the implant in the pterygoid area; however, recognition of anatomical and radiological markers and safety limits is very important for this procedure [23].

The pterygoid implant has been defined as '' implant placement in maxillary tubercle and pterygoid plate ''. These implants were first introduced by Tulasne in 1989 [24]. Length of these implants is between 15 and 20 mm and is usually 45 to 50 degrees from the horizontal plane. Usually, the region has a difficult structure of surgical procedure and pterygoid plates use a combination of osteotome and surgical piercing with long extensions to minimize bone density and the potential for damaging the vital structures [25].

Placed implants in the pterygoid region have high success rates, bone loss levels similar to traditional implants, minimal complications, and good acceptance by patients; therefore, it is an alternative to treat patients with the atrophic posterior maxilla. In a study by Riddell., *et al* [26]. placed 22 implants in the maxillary tuberosities area and reported 100% success after 12 years of follow-up.

Remaining anterior maxillary segment

The bone structure that occurs after the loss of teeth in the anterior region of maxilla makes it difficult to place the dental implants in similar positions as in natural teeth. Premaxilla, after tooth extraction, has lost 25% of its width in the first year and 40% and 60% in the first three years. Also, compact bone in vestibule can be broken during tooth extraction. Depending on the anatomy, implants are placed in more palatinal and superior positions [27]. For most maxillectomy patients, the ideal place for implants is residual premaxillary segment; this region is preferred because the anterior maxillary segment is opposite of most permanent part of the defect along the posterior lateral wall. In addition, most patients may have a satisfactory bone volume and density in pre-maxilla so that every effect is made to maintain this bone segment as much as possible [10].

In the present case study, the risk of increasing diameter or size of implants may be reduced in areas with a risk of resorption, in order to increase the retention of the obturator used in the defect region, the maxillary segment in the premaxillary region can be placed the implant and using bar or locator system can be provided retention [28].

Remaining alveolar crest

The alveolar crest is a piece of horseshoe-shaped bone covered with soft tissue that remains intact after the natural teeth are removed [29]. For the success of dental implants, a sufficient amount of bone in vertical and horizontal dimensions is the first condition for implant treatment, but it is difficult to place an implant when there is not enough bone. Remaining alveolar crest after hemimaxillectomy is suitable for implant placement in order to increase the comfort of the obturator. In many studies, two or more implants have been inserted into the alveolar crest and retained [30].

Tuber maxilla

Maxillary tuberosity region is increasingly involved in pre-prosthetic surgery as part of a comprehensive implant treatment planning when more complex surgeries (elevation of the sinus base) are rejected by patients due to the high costs, longer recovery time and increased risk of intraoperative complications [31].

The maxillary tubular region is considered only when there is insufficient bone in residual pre-maxilla. Since bone is not very dense in the maxillary tuber, developing bone-implant interface may not provide a predictable outcome, as demonstrated by the high failure rates in stage II surgery. Because of this factor, some clinicians have suggested placing longer and inclined implants on pterygoid plates. The toothless posterior alveolar crest can be used as an alternative site for implants if there is at least 10 mm bone under the maxillary sinus [10]. In a study, they concluded that the implant could be placed in tuber region when the amount of bone was not sufficient for implant placement in the maxilla [32].

Implant types

Traditional implants

The emergence of osseointegration was an important benefit in this rehabilitation area by initially implanting implants into the existing maxillary bone. Traditional dental implants are the most commonly used implants in dentistry. For patients with one or more missing teeth, dental implants offer the best restorative option available. Traditional dental implants are titanium screws placed in the jaw bone and attached to restoration. Implants are the only restorative treatment method that replaces the crown as well as the tooth root [33].

Mini dental implants

Mini dental implants have been used in dentistry for nearly 20 years. Mini dental implants were first introduced in 1994 by Barber and Seckinger, and 2.9 mm in diameter. Following this study, Sendax's study used a single piece and a diameter of 1.8 mm [34]. These implants also called small or narrow-diameter implants, are narrower than the most commonly used dental implants.

Like conventional implants, it provides support for mini implants, crowns, bridges and removable dentures. They are widely used to stabilize removable prosthesis and obturator, which have common bone atrophy and have maxillectomy, giving the ability to chew and speak with confidence. The biggest disadvantage of long-term use of mini-dental implants due to different weight distribution is breakage and pressure of the jawbone to a little more than that of conventional implants. Therefore, it usually requires longer recovery times [35]. The use of mini dental implants is an alternative treatment method in order to ensure the retention of the prosthetic restoration applied for individuals with lip and palate defects. Soğancı., *et al.* examined the stress distribution of cortical bone using mini-dental implants with a different number of 2.4 mm diameter and 15 mm length in unilateral toothless cleft palate patients. They observed the most intense stress value in the vicinity of the implants in overdenture prostheses supported by 6 mini implants [36]. Balaji., *et al* [37]. used mini-dental implants in the absence of single tooth deficiency in which mesiodistal distance was insufficient for traditional implant placement. They stated that the success rate was high and mini dental implants could be used as an alternative treatment.

Zygomatic implants

Zygomatic implants are indicated for the treatment of patients after oncological treatment, after injuries, after congenital malformations, and in patients with severe alveolar bone loss in the maxilla. It is also an adequate remedy for patients with systemic pathology causing severe maxillary atrophy such as maxillary resections and cleft palate or epidermolysis bullosa [38].

Zygomatic implants are implants made of titanium of 8 different lengths ranging from 30 to 52.5 mm, placed in the zygomatic and maxillary alveolar bone. The diameter of the portion located in alveolar bone is 4.5 mm and diameter of the apical part in zygomatic bone is 4 mm. There is a neck of 45 ° to tolerate opening between zygomatic bone and maxilla [39]. zygomatic implants were developed for patients with total or partial maxillary toothlessness with inadequate bone mass and excessive resorption in the sinus region. This implant is fixed to zygoma, so it is thought to be useful in the retention of obturators in maxillary defects [11]. In 1997, Weischer., *et al* [20]. have emphasized that zygoma may be used as a support structure in prosthetic rehabilitation in patients undergoing maxillectomy. However, in 1998, Branemark [40] first introduced zygoma implants as an alternative treatment option in the highly resorbed alveolar crest. American Prosthodontists College [41] provides patients with an accelerated and predictable option in various clinical cases with multiple configurations, with zygomatic implants enabling patients to improve their quality of life.

Implant superstructure retention mechanism for obturator

Bar systems

The use of bar-holding systems in implant-supported complete dentures began in the early 1980s. Bar holders were developed from prosthodontic treatment planning philosophies philosophers of root or tooth supported prostheses in the 1970s and 1980s [42]. Bar holder systems are indicated for prostheses where the excessive resorptive crest is present in upper and lower jaws, in cases of the oval crest, bone and/or soft tissue partial resection, where retention and stability are desired. It is contraindicated in cases where the patient's economic status is inadequate (necessity of many implants) and in cases where oral hygiene is not obtained well. While it is considered as an advantage that they have a positive effect on retention and stability, they are not economical and the complexity of the construction phases is disadvantageous [43]. The bar attachments applied to the lower and upper jaws are obtained either by hand or by casting. Bar systems include a standard abutment, gold cylinder, and bars with different sections.

Bar holder types: U-shaped section bar, round section bar, and egg section. Over time wear of plastic clips to lose their retention, metal clips or metal housing plastic clips and O-Ring attachments makes its use more attractive [44].

Ball attachment

They are easiest to use and most popular precision holder systems are ball head holders. They take less space than bars, they get more support from tissue and they are cheaper. It is usually recommended if the patient's total prosthesis does not need to be changed and the implant has been inserted to enhance retention [45]. Stud atçaman/O-rings/ball attachments provide optimal retention and stability for implant overdenture prostheses and are very easy to use [46]. Factors affecting the satisfaction of patients with ball attachment restraint systems; where the interocclusal distance is small, extremely contoured prostheses, situations where vertical dimension is increased, cases of fractures or fractures of artificial teeth adjacent to holders, separating the holders from the prostheses, in cases fractures of the prosthesis [47].

Locator holder system consists of Locator abutments suitable for all implant diameters and sizes, metal holder with black plastic, transparent, pink, blue, green and red locator holders with different retention forces [48]. The dual retention of locator attachment system provides more surface area for retention than other attachments. It also allows the patient to easily attach parts of the implant [30].

Magnet systems

Magnet holders provide an alternative retention mechanism for implant-supported complete dentures. Magnet holders have two components. The portion of magnet that is left in the prosthesis, or the portion consisting of a non-magnet metal (magnetizable) which is drawn by a magnet on the implant or the implant [49]. Prosthesis with magnet retaining is that they can be applied independently of the path of the prosthesis. It is also used in the presence of non-parallel angled implants. Due to these properties, systems with magnet holder can be used alone or in combination with other types of holding systems [12]. Tokuhisa *et al* [50]. reported that the prosthesis allowed for movement in all directions (universal flexibility) and that the lateral force transmission to the natural tooth or implant in the prosthetic prostheses with magnet retainers was minimal. When compared with ball head and bar connections, the retention and patient satisfaction values of the systems with magnet holder are less determined.

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