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Implant-retained maxillary overdentures

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Patients seek tooth replacement to address issues related to comfort, function, or esthetics. As patients experience the loss of teeth the dentist's ability to provide restorations that meet their desires diminish. In response to this situation dentists have diligently sought to establish new approaches to address the edentulous or partially edentulous condition [1–3].

The dentist's reduced ability to meet the patient's needs relates to the valuable service that natural teeth provide when dental prostheses are made. Natural teeth support dental prostheses from forces toward the edentulous ridges, they retain prostheses from forces that tend to dislodge the prosthesis, and they stabilize prostheses to resist all other non-axial forces [4]. These functions—support, retention and stability—are provided by teeth in combination with the soft and hard tissues of the residual ridges in removable prosthodontics.

When the teeth are lost, the patient may experience difficulty as the residual structures are substituted for the natural dentition. Rather than having clasps, edentulous patients rely on ridges, buccal shelves, and hard palates for retention and support. Peripheral seal becomes critical when complete denture retention is considered. Although the vertical projections of the residual ridges may provide stability, the patient certainly experiences a reduction in stability compared to that provided by guiding planes in the natural dentition. Thus the transition from the dentate state to partially or complete edentulism is a path that is fraught with concern on the part of the patient. The patient's emphasis may change from function, a relatively objective problem, to the more subjective concerns of esthetics and comfort. This transition from objective [5,6] to subjective emphasis creates an ever-increasing challenge for the dentist to satisfy the patient's requests.

Classically, an overdenture has been used for patients who find themselves in this transition from dentate to edentulous [7,8]. By retaining a few

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strategically positioned roots, the dentist is able to address the patient's desires better. Perhaps it is the psychosocial advantages of tooth preservation (even if it is only a portion of a tooth) that makes the overdenture a viable consideration [6]. Retained roots allow the patient to avoid the clichéd stigma of being long in the tooth, thereby retaining a connection with youth [9–11]. The overdenture carries with it some complex dental problems, however.

Retention of natural tooth roots offers a number of potential benefits. These roots seem to slow the process of residual ridge resorption. They provide the patient with better proprioception through the retention of the periodontal ligament fibers [9,12–15]. If retentive components are incorporated in the overdenture abutment teeth, denture retention increases profoundly. The natural tooth roots support the prosthesis, and the increased height of the alveolus surrounding the root, in conjunction with the root itself, enhances stability.

The benefits obtained from the retention of natural tooth roots used to support an overdenture seem to be numerous. Unfortunately a few factors may make the use of natural tooth roots less appealing. Teeth remain susceptible to caries (Fig. 1) and periodontal disease [16–20]. To establish a favorable crown-to-root ratio, root canal therapy may be necessary before crown resection. Retentive components, which may be intracoronal or extracoronal, generally demand the use of a cast restoration that will be luted to the retained root. The need for root canal therapy and cast restorations significantly increases the cost of therapy. Perhaps the most problematic situation occurs when alveolar bone creates an undercut facial to the retained root [21]. Bony undercuts may prevent a favorable path of p1rosthesis insertion unless the undercut area is blocked out, and such blockout creates a void between the intaglio surface of the overdenture and the underlying tissues. The void, or dead space, becomes a harbor for food impacting and interferes with the peripheral seal of the denture.

Fig. 1. Edentulous maxillary arch with carious overdenture teeth. Lack of patient compliance with addition of fluoride to the prosthesis on a daily basis can result in eventual loss of teeth and of any supportive or stabilizing effect contributed by an overdenture prosthesis.

Patients who lose many of their natural teeth do so for a reason. In most instances the reason for tooth loss is neglect. Neglect manifests as poor oral hygiene or avoidance of proper dental care. Either of these situations will doom the overdenture abutment teeth to rapid deterioration. Conversely, success of an overdenture demands excellent patient cooperation and ongoing professional care. This dichotomous situation—the need a for strong commitment to oral hygiene and ongoing dental care in patients who often demonstrate an inability or lack of desire to make this commitment—has perplexed clinicians considering the overdenture option.

Fortunately dental implants offer the clinician many of the benefits of retained roots while avoiding a number of the liabilities from those roots [22]. Implants are obviously not susceptible to dental caries. Authors describe a decreased risk of progressive bone loss around implants [23,24]. Because implants lack a periodontal support system, they can be used in patients who have experienced tooth loss as a result of periodontitis, and implant placement seems to provide predictable success for patients with a wide variety of medical conditions [25–30]. The remainder of this article concentrates on the use of implants to support and retain dental prostheses.

Maxillary implant-supported overdentures

Normally a maxillary denture is retained because of a differential between atmospheric pressure and the pressure between the denture and the supporting tissue. There is no vacuum when the denture is at rest, but a vacuum is created in response to dislodging forces. Denture adaptation is coupled with the adhesion between the denture, saliva, and supporting tissue to provide retention. Close adaptation of denture to tissue, cohesion of saliva, and maximal soft tissue coverage establish the magnitude of denture retention [31–44]. Contact between the denture periphery and the soft tissue establishes a peripheral seal [45]. This seal assists in retaining the denture.

With an implant-supported overdenture, the implants alter the potential for denture retention. Normally a denture is supported by soft tissue that has a degree of differential compressibility [36,46–48]. This compressibility may be a favorable factor in that it compensates for minor fit discrepancies caused by denture processing. The use of implants to support a prosthesis negates the compressibility of the soft tissue because the implants are essentially immobile [22]. Vertical loading of implants provides no displacement of the prosthesis toward the tissue unless specific components are selected that allow movement toward the underlying tissue. When designing a prosthesis, the clinician must decide whether to allow or to prevent tissueward movement, because either course has advantages and disadvantages.

Movement of the prosthesis toward the tissue is generally favored when implants are not distributed throughout the arch. For example, if implants are placed in the anterior maxilla (Fig. 2), the prosthesis will fulcrum over the implants as it compresses the posterior tissue under functional load. If

Fig. 2. Anterior implant placement in this edentulous maxilla takes advantage of the remaining volume of maxillary bone anterior to the maxillary sinus bilaterally. Unfortunately, the connecting bar and prosthesis must incorporate a rotational design because of the functional forces that are posterior to and therefore outside the implant support.

the movement of the prosthesis is prohibited through the use of rigid retentive components, the terminal implants are placed under adverse stress conditions. These implants experience torsional forces that could lead to component failure or could contribute to implant fracture.

When implants are distributed throughout the maxillary arch, there is no reason to allow movement toward the underlying tissue. Movement of the prosthesis is unlikely to be free enough to respond to functional movement. Consequently the prosthesis is likely to become compressed onto the underlying soft tissue, being held in this position by the retentive components. The underlying tissue is likely to respond to this pressure by undergoing inflammation followed by atrophy [49].

When an overdenture is planned in the maxillary arch, the clinician must plan for the use of retentive components that are connected to the implants and are used to secure the prosthesis [50–57]. This precaution is required because the denture must resist the forces of gravity, and the normal retentive mechanisms are not in effect. Retention of the overdenture is accomplished through the use of mechanical attachments (Fig. 3). These attachments may be rigid or nonrigid, with the choice dictated by the number and distribution of implants. If rigid attachments are used, it is likely that an implant-connecting framework will be made that mates precisely to the overlying overdenture. The combination of connecting bar and precision overdenture provides retention, support, and stability that rivals that found with fixed prostheses.

Fig. 3. Maxillary overdenture intaglio or fitting surface showing distal attachments and labial path-of-insertion guides. The attachments provide retention, and the labial guides provide guidance for seating as well as resistance to dislodgment because they are oriented not to coincide with the opening axis of the lower jaw. This orientation allows the guides to resist any potential pull of the prosthesis away from the connecting bar caused by action of adhesive foods. The guides also provide a stabilizing effect through accurate fitting with the overdenture framework.

Clinical research findings from overdenture use

The potential advantages in using implants for the edentulous maxilla can best be demonstrated by applying implants and following patient performance, watching for important clinical differences. Ideally, the implants would be compared with some other standard form of care, indicating which method works better. Sometimes the better method can be determined by observing which causes fewer adverse outcomes.

Caution needs to be exercised in considering such studies, because the way they are conducted influences whether the differences shown result from the different treatments or from some other feature (often a feature not even known or realized).

When available, information from randomized, controlled trials should be used to guide clinical decisions. Randomized, controlled trials increase the chance that the findings shown are related to treatment differences. The following limited review looks at studies specifically related to important clinical questions regarding maxillary implant overdentures.

Are patients better off with maxillary implant-retained overdentures or conventional dentures?

The decision to offer implant prostheses for the edentulous maxilla should be based on the patient's need. Not all patients can be provided with conventional dentures that meet their needs or desires. Although in some patients the functional and psychosocial limitations seen with mandibular complete dentures are significantly improved by using implants to stabilize

mandibular overdentures [58,59], the same may not be true for maxillary complete dentures. In a crossover study comparing patient-based outcomes between patients receiving new conventional maxillary dentures and patients receiving implant prostheses of two designs, the ratings given to the implant prostheses were not significantly higher than those given for the new conventional denture prostheses [60]. Although the study may not have had sufficient numbers of patients to actually show a difference, it is possible that implant prostheses in the maxilla have the best chance of improving outcomes for patients who struggle with conventional prostheses. Therefore, patients are better off with maxillary implant-retained overdentures when their experience with conventional dentures has been poor.

Should maxillary implant prostheses be fixed or removable?

The clinical procedures required for providing a fixed implant prosthesis are different from those required for a removable implant prosthesis. Also, the patient homecare procedures differ, and hygiene procedures are generally more difficult for a fixed prosthesis. Consequently, it would be helpful to know whether clinical outcomes between the two prosthesis designs strongly favor one design over the other. A significant difference in outcome specifically related to prosthesis design is an important influence in deciding between types of prostheses.

In a unique crossover study in which the same group of patients was allowed to use a removable prosthesis and a fixed prosthesis at different times, both general satisfaction and patient preference were used to determine differences in the prostheses [61]. The overdenture prostheses received significantly higher satisfaction ratings than the fixed prostheses, and at the conclusion of the study 69% of the patients chose to use the overdenture prosthesis permanently.

Other studies have supported this finding and point out that implant overdenture prostheses have advantages related to hygiene access, speech, and esthetics when compared with fixed prostheses. Consequently, when considering implant prostheses, a removable overdenture prosthesis offers advantages for the average patient with an edentulous maxilla.

Is it better to have the implants lone-standing or connected by a bar for a maxillary overdenture?

When the decision has been made to provide the patient a maxillary implant overdenture, does the added cost of connecting the implants with a bar, compared with using individual ball attachments on unconnected implants, improve the success of treatment?

The difficulty in answering this type of question relates to the clinical reasons why one design is chosen instead of the other in many situations. When implant failure occurs before prosthodontic treatment, it is more

common to leave implants unconnected and to attach the prosthesis using various attachment mechanisms. Consequently, the decision regarding prosthesis design is based on a compromised clinical situation. The outcomes of treatment may be influenced as much by the compromise (eg, fewer implants than desired or poor implant distribution.) than by the ultimate prosthesis design.

One study followed edentulous maxillary implant prostheses of various designs for 3 years, making note of prosthesis failure defined as the need to remake the prosthesis for any reason [62]. A total of 100 prostheses were provided and followed for 36 months of clinical loading. Of this total, 10.7% were dentures using a stud or ball retained attachment without a connecting bar. In this group, 81.8% of the prostheses survived the 36-month observation period, compared with 94.6% in the bar-supported group. The authors report that the alternative prosthesis designs were used when implant loss or insufficient bone did not allow the bar-supported design to be used. Because of the compromised condition of the patients in whom the prosthesis without a supporting bar was used, it is difficult to know whether connecting implants improves the chance for success. In general, studies have supported this finding of improved performance when implants are connected in the edentulous maxilla [63].

Treatment planning for overdentures

When the patient's chief complaint identifies issues related to retention, support, or stability of a prosthesis, the clinician must consider mechanisms to improve these physical properties. Traditionally, in the edentulous patient the methods that have been used to improve retention, support, and stability have centered on enhancement of the basal tissues. Vestibuloplasty, ridge augmentation, and grafting procedures have been used with variable success [58–66]. With the advent of implants that undergo osseointegration, the clinician's ability to improve retention, support, and stability predictably has increased dramatically [22,67–74].

The decision whether to use implants to support fixed prostheses or overdenture prostheses depends on a number of factors. The number and location of implants may dictate the type of prosthesis that can be made. For example, a fixed prosthesis demands that the implants provide all support and retention for the prosthesis; soft tissues simply fill the space between the prosthesis and the underlying bone. Consequently if the number of implants is insufficient to support or retain the prosthesis entirely, an overdenture design is indicated, because it will gain some support, retention, or stability from the residual soft and hard tissues. Likewise, if the patient requires lip support, a fixed prosthesis is unlikely to provide this support if it is needed near the area of the vestibular reflection. Lip and facial support is often the deciding factor when the clinician must choose between fixed or overdenture prostheses. Fixed prostheses have limited ability to compensate

for vertical and horizontal bone loss. The loss of alveolar bone may complicate normal phonation. The overdenture approach provides simple prosthetic replacement for these alveolar defects.

The cost of the prosthesis may be a factor. In the maxilla the overdenture may require a number of implants that approaches that of the fixed prosthesis, and the design of the overdenture can be as complex or more complex than the fixed prosthesis, sometimes making the cost savings with an overdenture negligible. Neither prosthesis design is immune to ongoing maintenance considerations. Fixed and removable prostheses may experience complications related to material failure, component loosening, component breakage, or soft and hard tissue changes. Removable prostheses are generally retained by components that will exhibit wear. Facility of component replacement depends on the type of components chosen. Some retentive elements are easily replaced and readily available; other components are custom-designed, making replacement difficult without replacement of the custom elements. These factors may further complicate blanket statements regarding the cost of long-term maintenance.

Ultimately the choice between a fixed prosthesis and an overdenture prosthesis supported by implants is made by the patient. If both options are feasible, it is the patient's responsibility to choose one design or the other based upon an informed level of consent.

Once the overdenture option is chosen, the clinician must develop a plan for the number and location of implants required for the prosthesis. Before implant surgery the clinician in charge of the definitive restoration should be involved in the decisions regarding the number and location of the implants. Treatment planning demands that the clinician obtain appropriate radiographs, images, diagnostic casts, diagnostic mountings, wax trial dentures, and patient approval of the anticipated tooth arrangement. Once these data are gathered, a surgical guide can be fabricated to assist the surgical team in locating the most favorable implant positions. Surgical guides should be relatively easy to use, be simple to place, and allow sufficient flexibility so that the surgeon is not limited to specific implant sites that may not be available. An exception to this statement occurs when recently developed rapid CT prototyping techniques are used to ensure that implant positioning can be established within very tight tolerances. Because this technology is in early stages of development, it is unlikely that it will be widely available to clinicians in the very near future. Therefore the recommendations for surgical guides that allow surgical options remain the standard of the day.

The number and location of implants depends on the results of the diagnostic data and the ultimate surgical plan. If there is no plan for bone augmentation, bone grafting, or implant site development, the number of implants is limited to the number that can be placed in the available bone. Likewise, in this situation, the location of the implants is dictated by the location of the available bone. Surgery performed before implant placement to enhance the possibility of implant placement may allow the clinician to

place implants more ideally rather than being limited to specific sites on the basis of bone availability. The clinicians must understand the exact situation relative to grafting, augmentation, or site development before the final plan is established rather than depending on decision making at the time of surgery. The former approach creates well-developed plans; the latter results in confusion for the patient and the clinician in charge of creating the final restoration.

When considering ideal implant number and location, it is easy to suggest that the prosthesis be supported widely and completely. Implants located in the first molar and cuspid locations bilaterally would provide this level of support. Branemark et al [75] have suggested that four ideally placed implants in the maxilla can support a fixed prosthesis, but the authors consider four to be the minimum number of implants for reliable support of a prosthesis [70]. The authors prefer to place six implants to ensure against dramatic changes in prosthesis design should an implant fail to integrate. The reasoning is that if one of four implants were to fail, that implant is clearly strategic to the ultimate prosthetic design. Its failure precludes total implant support for the prosthesis and relegates the patient to a prosthesis that is supported by implants and residual tissue. Such a design is considered to be a compromise that should be planned against if at all possible.

In some patients the ideal placement of six implants is not possible. The residual anatomy may not allow ideal location or number of implants, and the patient is unable or unwilling to undergo implant site development procedures in the form of grafting or augmentation to allow the placement of this number of ideally located implants. In such a situation the use of a prosthesis that is supported by implants and residual tissues becomes inevitable. The clinician must use retentive elements connected to the implants that allow prosthesis movement. Failure to allow for this movement will subject the terminal implants to high mechanical stress that could result in catastrophic failure. As the clinician chooses the appropriate components, the implant connection must also be carefully considered. When residual structures are recruited for support, there will be a fulcrum line through the terminal aspect of the most posterior implants bilaterally. Creating an implant-connected rigid splint that prevents rotation about this fulcrum line exaggerates stresses within the system that may be unfavorable. Such a situation is improved by physiologic adjustments to compensate for tissueward movement.

Technique

The technique employed for the fabrication of an overdenture prosthesis is essentially the same as that used to fabricate a complete denture. The authors favor using implant-connecting bars (Fig. 4) to avoid concentrating stress on individual implants because such concentration of stress could affect the integrity of screw joints or increase the risk of implant fracture.

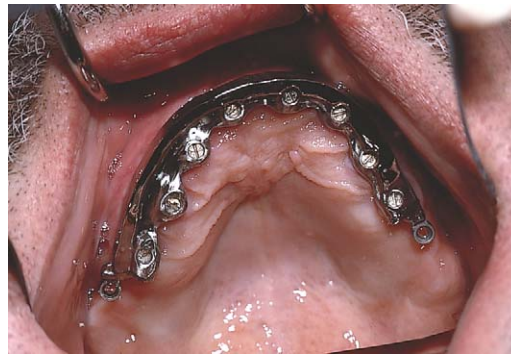

Fig. 4. Eight maxillary implants connected from first molar to first molar. This wide distribution of connected implants provides considerable resistance to stress distribution for a maximal functional area.

Impressions, maxillomandibular relationship records, and wax trial dentures are made before the design of the implant-connecting bar is established (Fig. 5) because the final tooth position determines the amount of space available for the connecting bar. Fabrication of a connecting bar before confirmation by a wax trial denture forces the clinician to fit the teeth around the bar rather than fitting the bar to the artificial teeth. Because tooth position is established to provide favorable functional and esthetic results, premature bar fabrication condemns the clinician to using compensatory techniques rather than working with the ideal tooth position.

A few special considerations exist. Final impressions are made in a border-molded impression tray. The authors favor open impression trays that allow the rigid splinting of transfer components through the use of pattern resin

Fig. 5. Presurgical trial denture in which teeth have been arranged for intraoral check. Clinical satisfaction of horizontal and vertical jaw relationship requirements, esthetic needs, and occlusal plane location should be verified. Only after such verification can implants be placed that will accommodate and not dictate tooth positions.

(Fig. 6) or impression plaster. Once these transfer components are splinted, they cannot be removed from the impression without permanent deformation of the impression material. The open impression tray allows retentive screws to be removed once the impression material sets. With retentive screws removed, the impression may be removed from the oral cavity. Implant or abutment analogues are then connected to the transfer components before fabrication of the definitive working cast. Frequently the connections that are captured in the impression are located beneath the soft tissue margin. In this case, soft tissue casts must be made.

The authors favor impressions that are made directly to the endosseous implant because this practice allows abutment selection following confirmation of tooth position through the use of the wax trial denture. Alternatively the transmucosal abutments could be chosen before the making of the final impression, but doing so limits the clinician to those abutment choices that are made without a full understanding of the final tooth position. If, after confirmation of tooth position, an abutment must be changed, the clinician must make an altered cast impression to capture the new abutment.

Recording of the maxillomandibular relationship is facilitated by rigid retention of the baseplate to the underlying implants. The wax trial denture is likewise fixed to the implants to ensure accurate confirmation of records. After tooth position is confirmed, facial or occlusal matrices are created to record tooth position. With this matrix as a guide, the clinician can determine the space available for connecting bars and restorative materials.

There are two basic designs for implant-connecting bars. One design allows overdenture movement around the bar, and the other design restricts or prohibits such movement. Choice of one design or the other depends on the number and location of implants along with the available space for prosthetic materials. When the implants are aligned in a relatively rectilinear manner,

Fig. 6. Impressions should transfer implant and residual ridge relationships accurately. The implants must be connected with a framework that does not create stress when attached. This absence of stress can be accomplished by rigidly connecting the transfer copings using resin (before impressing with an elastomer) or by using a rigid impression material, such as plaster.

the clinician must anticipate that the prosthesis will fulcrum around the implant-connecting bar. An acrylic-based overdenture may then be indicated to facilitate physiologic adjustment of the prosthesis as it moves under functional load. Conversely, when implant placement creates a broad and favorable distribution of six or more implants, it is unlikely that the prosthesis will move under functional load. In that situation it is prudent to consider a design for the implant-connecting bar that uses relatively parallel milled walls to create one distinct path of insertion for the overdenture. The overdenture itself is likely to have a cast metal structure to which the denture teeth are connected. This cast metal overdenture base will be made to fit intimately to the underlying connecting bar. This fit is accomplished by duplicating the connecting bar in a refractory material and creating a direct waxup to this refractory cast. The overdenture casting is then made to this refractory cast, thereby ensuring close adaptation to the implant-connecting bar.

Retention of the overdenture is enhanced if the implant-connecting bar establishes only one path of insertion. The path of insertion should not parallel the opening and closing arch (see Fig. 3). Creating a path of insertion that does not parallel the opening arc ensures that the metal base of the overdenture prosthesis will bind on the implant-connecting bar during opening movements. This binding enhances prosthesis retention and reduces the wear that would normally occur on the prosthetic retentive elements.

The fit of the implants to the implant-connecting bars should be confirmed (Fig. 7) through visual, tactile, or radiographic methods. Once the fit of the connecting bar is confirmed, the fit of the overdenture to the bar is evaluated, and final tooth arrangement is reconfirmed with the patient. The overdenture is then processed using conventional techniques.

Fig. 7. Visual inspection of the fitting accuracy of the connecting bar can be complemented by digital measures. Alternate pressure over bilateral regions of the framework can reveal lack of intimate fit as demonstrated by a rocking motion. Use of a single screw to one region may create vertical lift to a distant region if the framework is inaccurate. Horizontal inaccuracy also can be problematic and is more difficult to detect at times.

Fig. 8. Maxillary implant overdenture at insertion. Adequate retention, stability, and support should be evaluated clinically; making sure no tissue pressure is present. This assurance may involve adjusting the prosthesis using pressure-indicating techniques when functional movements are attempted to determine whether tissue contact exists that could produce trauma. The patient should be instructed in placement and removal techniques and in the hygiene measures required for this construction.

Overdenture insertion is accomplished using standard techniques with close attention to the need for physiologic adjustment (Fig. 8). Follow-up care is likely to be less involved than with conventional dentures, because the implants reduce or eliminate soft tissue compression, thereby limiting soft tissue irritation.

Summary

Overdentures supported by osseointegrated implants overcome many of the complications observed with overdentures supported by natural teeth. Dental implants are free of biologic consequences associated with natural teeth, such as dental caries and periodontal disease. Bone undercuts adjacent to implants do not mimic those found adjacent to natural tooth roots. Implants are used to provide predictable retention, support, and stability for overdenture prostheses. When lip or facial support is required, the overdenture is the treatment of choice. Likewise the overdenture may improve phonetic deficiencies associated with alveolar bone loss.

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