Mandibular implant-supported overdentures: attachment systems, and number and locations of implants – Part I

Abstract
The use of dental implants in replacing missing teeth is an integral part of restorative dental treatment. Use of conventional complete dentures is associated with several problems such as lack of denture stability, support and retention. However, when mandibular complete dentures were used with two or more implants, an improvement in the patients’ psychological and social well-being could be seen. There is general consensus that removable implant-supported overdentures (RISOs) with two implants should be considered as the first-choice standard of care for an edentulous mandible. This treatment option necessitates the use of attachment systems that connect the complete denture to the implant. Nevertheless, each attachment system has its inherent advantages and disadvantages, which should be considered when choosing a system. The first part of this article provides an overview on options available to restore the mandibular edentulous arch with dental implants. Different types of attachment systems, their features and drawbacks are also reviewed.

Keywords: dental implant; mandibular overdenture; implant-supported overdenture; implant-retained overdenture; overdenture attachment system; patient satisfaction.

Introduction

Despite the decline in the prevalence of edentulism (complete loss of teeth), there is a high number of patients who are completely edentulous and wearing conventional complete dentures. Before the era of dental implants, complete edentulous jaws were restored with conventional complete dentures, as this was the only option available. Use of conventional complete dentures is associated with several problems, such as lack of denture stability, support and retention. These problems lead to discomfort, reduction in chewing ability and, at times, may be socially embarrassing. Consequently, the patients’ psychological and social well-being are negatively affected. In certain clinical situations, denture fixatives may offer a solution, but this approach is not always practical or cost-effective. Therefore, several surgical techniques have been used to improve the conventional complete denture outcome. However, surgical approaches are not without risks and may lead to several complications and improper treatment results. Thus, dental implants may provide a solution to these problems. The routine use of an implant with a complete denture is associated with improvements in retention, stability, function, perception and comfort. Hence, an edentulous mandible may be restored with a fixed or removable implant-supported complete denture. The fixed prosthesis has the advantage of being secured to the implants and is not removed by the patient. It is indicated when the bone volume and quality are adequate to place the required number of implants (usually four or more). When all other factors, such as complexity and costs of such treatment, are considered, the FISO is a favourable option for many patients. A fixed-cantilever prosthesis can be used when four implants are placed in the anterior region of the mandible. More implants, which are well distributed in the anterior and posterior regions of the mandible, can also be used. The FISO design results in reduction in soft tissue damage and the tissue coverage by the prosthesis is reduced. However, the differences in surgery and costs between the removable and fixed prostheses should be considered when a comparison between the two is made. FISOs are of two basic types: hybrid and porcelain-metal. The hybrid prosthesis is made of metal substructure, acrylic and denture teeth. It is indicated when the vertical restorative space is adequate to accommodate the prosthesis, or even increased, as this increase can be filled with acrylic to achieve good aesthetic and bone loss, and both require replacement. Therefore, RISOs may provide a solution to the problems linked to the use of conventional complete dentures or FISOs.

The use of the mandibular conventional complete denture is more problematic than that of the maxillary conventional denture due to several factors such as thin mucosal coverage of the edentulous ridge, a reduced support area and the mobility of the floor of the mouth, the movement of the mandible and the tongue. These factors make the use of dental implants and attachments a common practice to overcome their adverse consequences. The aim of this article is to provide the reader with an overview of the prosthetic options available to restore the edentulous mandible. Different attachment systems, which are commonly used with RISOs, and factors that should be considered when a treatment plan is made, are also presented.

Fixed implant-supported/retained overdentures

As the name indicates, this type of prosthesis cannot be removed by the patient. It is indicated when the bone volume and quality are adequate to place the required number of implants (usually four or more). When all other factors, such as complexity and costs of such treatment, are considered, the FISO is a favourable option for many patients. A fixed-cantilever prosthesis can be used when four implants are placed in the anterior region of the mandible. More implants, which are well distributed in the anterior and posterior regions of the mandible, can also be used. The FISO design results in reduction in soft tissue damage and the tissue coverage by the prosthesis is reduced. However, the differences in surgery and costs between the removable and fixed prostheses should be considered when a comparison between the two is made. FISOs are of two basic types: hybrid and porcelain-metal. The hybrid prosthesis is made of metal substructure, acrylic and denture teeth. It is indicated when the vertical restorative space is adequate to accommodate the prosthesis, or even increased, as this increase can be filled with acrylic to achieve good aesthetic

### TABLE 1: Comparisons between RISOs and FISOs that are used in restoring the edentulous mandible.

<table>
<thead>
<tr>
<th>Removable implant-supported overdenture (RISO)</th>
<th>Fixed implant-supported overdenture (FISO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can be removed by the patient</td>
<td>Cannot be removed by the patient</td>
</tr>
<tr>
<td>May be implant-supported or implant-tissue-supported</td>
<td>Only implant-supported</td>
</tr>
<tr>
<td>Different attachment types: individual or splinted</td>
<td>Two types: hybrid or porcelain-fused-to-metal</td>
</tr>
<tr>
<td>Loss of soft and hard tissue can be compensated for more easily</td>
<td>Loss of soft and hard tissue may be more difficult to compensate</td>
</tr>
<tr>
<td>Less expensive</td>
<td>More expensive</td>
</tr>
<tr>
<td>Less risk association</td>
<td>Associated with more risk to the patient and tissues</td>
</tr>
</tbody>
</table>

### FIGURE 1: A schematic representation of U-shaped mandibular edentulous ridges. Two implants are splinted with a single bar (A) around which a rotational movement of the overdenture may occur. In (B), four implants are placed in the anterior region of the mandible and connected with a bar of three segments. In this case, the bar can be cantilevered on both sides distal to the terminal abutments. In (C), four implants are placed on the same line. The spaces between the implants are limited, therefore, a clip with an adequate length that provides the required retention is not achievable (modified from Mericske-Stern et al.).

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**Note:** The table and figure are included for the purpose of context and analysis, but the main content focuses on the introduction to fixed implant-supported overdentures and their comparison with removable implant-supported overdentures.
results. Also, acrylic teeth are more resilient; therefore, they can reduce the impact of occlusal loading. On the other hand, the porcelain–metal fixed prosthesis is made of metal substructure and porcelain in a similar way as that used in the fabrication of the conventional porcelain fused to metal fixed prosthesis. It is more expensive than the hybrid and is difficult to make, but it is a useful option when the vertical restorative space is limited.

Removable implant-supported and implant tissue-supported overdentures

RISOs can be classified based on their source of support. The support during function may be obtained solely from the implants (mainly implant borne). In this case, the mucosa of the edentulous ridge does not take part in the supporting mechanism. Thus, RISOs should be denoted as implant-supported overdentures (Figure 1). Here, RISOs are usually entirely supported by multiple implants that are rigidly connected with a bar or a combination of bars, and other individual attachments. Therefore, an adequate number of implants is required. When an overdenture gains its support from both the implant and the tissue, it should be called an implant-tissue-supported overdenture (implant–mucosa-borne). In such cases, fewer implants are required. RISOs are attached to the implants, usually in the form of a bar, balls, Locators, magnets or telescopic attachments that permit movement of the overdenture during function and allow the mucosa of the residual ridge to be involved in dissipating the imposed force. Comparisons between RISOs and FISOs that are used in restoring the edentulous mandible are presented in Table 1.

Attachment systems

An attachment is a mechanical device used for the fixation, retention and stabilisation of a dental prosthesis. Five types of attachment systems are available and compatible with the main implant systems. Each attachment system has inherent attributes and drawbacks, and must be chosen with the particular patient profile in mind. The attachment systems that are commonly used with RISOs include: bar/clip; ball; resilient patrix; magnetic; and, telescopic. While the bar system is used in a splinting manner, the other attachments may be used individually (non-splinted) or in combination with the bar system (see below). Attachment systems may also be classified as resilient joints (connectors), when movements between parts of the attachment occur, or rigid joints, when such movements do not occur.

A. Bar/clip attachment system

In this system of attachment, the implants are connected with a bar, which represents the anchor that retains the denture and gives it support (Figures 1, 2 and 4). An element that fits on the bar is usually in the form of a clip (sleeve/channel) that is attached to the fitting surface of the overdenture. The bar may have various cross-sections, such as a reverse U-shape (rigid joint) or egg-shape or circle (resilient joint). The bar may be made from pre-milled plastic patterns (castable) or prefabricated from gold, such as the Dolder® bar. It may also be produced by CAD/CAM technology. The bar should be rigid enough to prevent its distortion. The clip may be rigid, e.g., made of gold (i.e., Dolder®), or resilient, e.g., made of plastic (i.e., Hader®).
With bar attachments, retention and stability are improved and less screw loosening and bone resorption occur. However, the most common mechanical complication of a bar attachment system is the loosening of abutment screws and attachment elements, as well as fractured dentures. In a situation where the use of two implants is recommended, the two implants are usually placed in a straight-line relationship and ideally on the crest of the ridge. A single straight bar is suitable in a patient with a square arch. However, a straight bar may not be a suitable option when the anterior part of the mandible is narrow, as the bar will impinge on the tongue space if the implants are placed in the canine region. Bar attachments can be used with multiple implants, i.e., four implants that are connected with three bars. They can also be used with four implants that are connected only on the sides with no cross arch connection. In situations where denture stability is not optimum (e.g., severely resorbed ridges), the stability can be improved by the use of bar attachments rather than the use of individual attachments. However, replacement of retentive parts when they are damaged may require sending the overdenture to the laboratory for repair, which leaves the patient without his/her denture for some time. Furthermore, a minimum of 12mm of vertical restorative space is usually required with this system. An example of a bar system that is widely used is the Dolder® bar (Sterngold), which has two different cross-sections – either parallel sides (reverse U-shaped) or gingival taper (egg-shaped). The Hader® bar (Sterngold) is an example of a resilient joint attachment. The clip is made of nylon that has three different colour-coded retention strengths. In general, resilient clips are easy to replace and cheaper than the metal clips. Conversely, replacement of a metal clip requires cutting the clip off the denture base and its pickup clinically using auto-polymerising acrylic. However, the nylon clip cannot be adjusted or reactivated as with the metal clip, and more frequent replacement may be required.

The CAD/CAM bars are made from a block of commercial pure titanium or titanium alloy. Commonly, the denture is made and the stone cast and wax setup are scanned optically to generate their exact 3D images. The information is sent to the milling machine to form the bar. The CAD/CAM technology reduces certain human errors; therefore, milled bars are usually of high quality and are porosity free. Examples of CAD/CAM milled bars are the ISUS® bar (Dentsply Prosthetics), the Nobel Procera® implant bar overdenture (NobelBiocare), and CAM StructSure® precision milled bars (Biomet 3i).

### B. Ball attachment systems

This system consists of a retentive patrix, which is part of an abutment that is screwed into the implant. An example of a ball system that is widely used is the Dolder® bar (Sterngold), which has two different cross-sections – either parallel sides (reverse U-shaped) or gingival taper (egg-shaped). The Hader® bar (Sterngold) is an example of a resilient joint attachment. The clip is made of nylon that has three different colour-coded retention strengths. In general, resilient clips are easy to replace and cheaper than the metal clips. Conversely, replacement of a metal clip requires cutting the clip off the denture base and its pickup clinically using auto-polymerising acrylic. However, the nylon clip cannot be adjusted or reactivated as with the metal clip, and more frequent replacement may be required.

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ball with different diameters and is typically made of metal alloy. The system also has a matrix, which is attached to the fitting surface of the denture and into which the patrix fits. The matrix can be composed of metal or resilient nylon. In one ball attachment system known as the O-ring attachment, a plastic ring is fitted in a groove inside a metal ring or socket, which is housed in the fitting surface of the denture.17

Some of the advantages of the ball system include ease of maintenance of hygiene around the implant, low cost, minimal chair-side time and ease of replacement of elements if required.15,19 However, one of the major disadvantages is that the patrix (ball) violates the vertical restorative space because of its high profile as the patrix is standing over the edentulous ridge. As with most other attachment systems, the ball system loses retention by wear of the matrices and patrices. Ball attachments are not suitable to use when the implants are not parallel (an angulation >15°) as retention is reduced significantly.

Examples of the ball attachment systems include the Dal-Ro® (BioMet 3i), the Dalbo (Dalbo-B® and Dalbo-classic®), the dental precision (Cendres+Métaux) and the Preci–Clix® (Preat Corp.). In principle, the Preci–Clix® is similar to the Hader® clip as both systems have resilient (nylon) matrices.

C. Attachments with resilient patrices

This type of attachment is like a resilient joint, as certain movements can occur in the joint. This is due to the fabrication material of the patrix element: nylon. One of the most widely used resilient attachments is called Locator® (Locator abutments, Zest Anchors). The Locator attachment system consists of an abutment, which is attached to the implant and contains a matrix. It also has a patrix element that is a polymer (nylon) insert, which is housed in a metal cap and provides retention. The cap is attached to the fitting surface of the denture and is made of titanium alloy (Figure 6). Locator attachment features what is known as a dual retention, as it consists of frictional and mechanical retentions. The frictional retention is provided by the nylon patrix head, which is slightly oversized compared to its matrix component. The mechanical retention is gained by a shallow undercut on abutment in which the outer margin of attachment is snapped (Figure 6). Therefore, the patrix, when fully seated in the matrix, engages the outer and inner surface of the matrix part (dual retention). Locator patrices have different retention ranges and strengths. This type of attachment is also characterised by its low vertical profile and the patrix has a self-aligning feature. Locator attachments can be used when the implants are non-parallel with angulations of up to 40° without a significant negative effect on their retention. Locators represent a universal resilient attachment as almost all types of denture movements can occur. This system can be easily repaired or replaced. Another example of a resilient patrix attachment system is the Extra-coronal Resilient Attachment (ERA®, Sterngold) (Table 2).

D. Magnetic attachments

This type of attachment system was originally used in the form of open-field aluminium-nickel-cobalt alloys that were embedded in the opposing maxillary and mandibular denture bases. The repellent forces would have kept the dentures in their intended position over the edentulous ridges. The retention that is obtained by this method is unreliable and weak, and the alloys are easily corroded.18 In more recent magnetic attachment systems, an abutment, also known as the keeper, is attached to the implant by a screw, while a magnet is attached to the fitting surface of the denture (Figure 7). The magnets are usually encapsulated by a corrosion-resistant tight sealer because corrosion of the magnet leads to loss of its attractive force.20 These relatively new magnetic attachment systems provide more stability and greater attractive forces than those produced by the old magnetic system (Table 2).

The magnetic attachment systems’ retentive capacity is not affected by the implant degree of divergence; thus, they can retain their attractive force when the implants are not parallel.19 It also has a low profile. By the use of this system, RISOs are relatively easy to place and remove, which is an advantage for elderly patients or those with a limited ability to tolerate or control removable dentures.21

E. Telescopic crown attachments

These attachments consist of a patrix, which is attached to the implant, and a matrix, which is contained within the fitting surface of the denture.17 Retention is achieved through frictional contact between the matrix and the patrix in a similar way to that which occurs in most of the other attachment systems (Table 2).18 One distinctive advantage of the telescopic attachment is that the retention gained by the telescopic system may be increased with time, which is possibly a result of the increased adaptation between the patrix and matrix (Table 2).16,22

When telescopic attachments are used, significant amounts of masticatory forces are transferred to the supporting implant, while a minimum masticatory loading is transferred to the residual alveolar ridge. Thus, the implant and its component are exposed to high stress that may lead to their fatigue and failure.

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