ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 6, Issue – 6, December - 2023, Page No. : 122 - 131

Current Trends and Future Prospects of Multiunit Abutments: A Literature Review

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Citation of this Article: Dr Venkat Nag, Dr Sarika P, Dr Bhavna Lokwani, Dr Manikandhan R, “Current Trends and Future Prospects of Multiunit Abutments: A Literature Review”, IJDSIR- December - 2023, Volume – 6, Issue - 6, P. No. 122 – 131.

Type of Publication: Review Article

Conflicts of Interest: Nil

Abstract

Multiunit abutments have revolutionized the restorative phase of implant dentistry, providing freedom of implant placement and helping to create passively fitting, screw-retained prosthetic options for full/partial arch rehabilitation. They offer numerous advantages over traditional single-unit abutments with enhanced aesthetic and functional outcomes. These abutments have become an integral part of modern implant dentistry but various aspects surrounding their design, types, biomechanical properties, functions, prosthetic screw concepts, clinical applications and procedures, limitations, and future research and innovation have not yet been discussed in the literature. A comprehensive literature search was performed with several keywords related to multiunit abutments and articles in English were included to narrow-down the information. Therefore, this review article aims to provide detailed insights about multi-unit abutments to facilitate informed decision-making by the clinician and compensate for the existing dearth of information.

Keywords: abutments, microgrooves, multiphase, multiunit

Introduction

Implant dentistry is a well-documented treatment for the replacement of partial or full arches with missing teeth.[1,2] It is a constantly evolving science in terms of both its methodology and material technology. Successful prosthetic rehabilitation of implants is of paramount importance to the longevity and durability of the provided treatment. Therefore, abutment selection has a significant impact on achieving functional and aesthetic harmony. The abutment is the portion of the implant that supports or retains the prosthesis or implant super structure.[3] This retention is achieved via two methods i.e. the prosthesis is either screw-retained or cement-retained. Both modalities have their benefits and shortcomings in clinical application.[4] In recent years, with the increased risk of implant failure due to biological complications such as peri-implantitis, mainly with cemented implant restorations, the advantages of retrievability and accessibility, have accelerated the use of screw-retained implant prosthesis. Due to these reasons and their apparently higher biological compatibility, screw-retained modalities are currently preferred.[5-8] When connecting several implants with a screw-retained prosthesis, there is a need for an interim part, a multi-unit abutment (MUA), to correct the differences in implant angles and to create a common path of insertion.

There is a dearth of literature on the complete description and various aspects of MUA despite their increasing use in clinical practice. The authors found very few studies and literally no review describing these abutments. Therefore, the aim of this article is to provide a detailed insight into the design and functional aspects of MUA and the potential future trends to facilitate informed decision-making by the clinician.

Materials and methods

The Medline database of the National Library of Medicine, the Scopus database, and Google Scholar search engine were searched for articles with the following keywords: 'implant abutments', 'multiphase abutments', 'two piece abutments', 'multiunit abutments'. The searches were limited to articles in English and no time period limit was applied.

History of MUA

The first MUA was introduced by Nobel Biocare for the Branemark implant system and was configured as a two-piece titanium abutment cylinder.[9] Currently, a one-piece abutment, which can be straight or angled, is commonly used. Several manufacturers have now developed their own versions of MUAs, including Biomet 3i, Straumann, Noris Medical, Bioline iMultiunit, and others.

Design of MUA

MUAs are a special kind of dental implant abutments used to connect multiple implant fixtures to a single screw-retained prosthesis.[10] These abutments possess a short cone and a wide shoulder for easy positioning of the prosthetic restoration.[11] The abutment is divided into several parts:[12]

Parts of MUA

1. Base/ Hex - fits into the internal core of the implant.
2. Head - protrudes and serves as the prosthetic retainer. It connects the MUA to prosthetic superstructure.
3. Collar - placed according to the height of peri-implant tissue based on the subcrestal depth of implant placement. It connects the base and the head.
4. Screw channel/s - house/s the prosthetic screw to fix the abutment. MUAs are composed of two screw channels: a) MUA to implant and b) MUA to prosthetic superstructure (Figure 1).

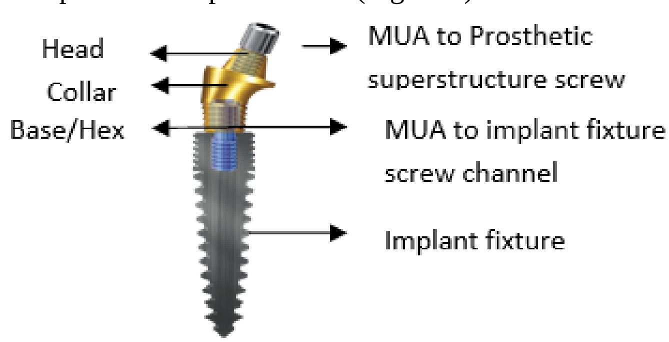

Figure 1: Design of MUA

The components used with MUAs include impression transfer copings (open tray and closed tray), MUA implant analogue, multiunit healing cap, scan body, titanium sleeve, plastic castable sleeve, multiunit Ti base, prosthetic screw and MUA to implant screw.

Types of MUAs:

The two main categories of MUAs are straight or angled.[11] Depending on angulations or alignments and varying bone conditions, the different abutment angulations (0°,9º, 18°, 30°, 40°, 50º, 60º) in several different collar heights can be utilized for restoration (Figure 2). They are most commonly used for a full arch replacement, all on 4, all on "X" with or without zygomatic dental implants.

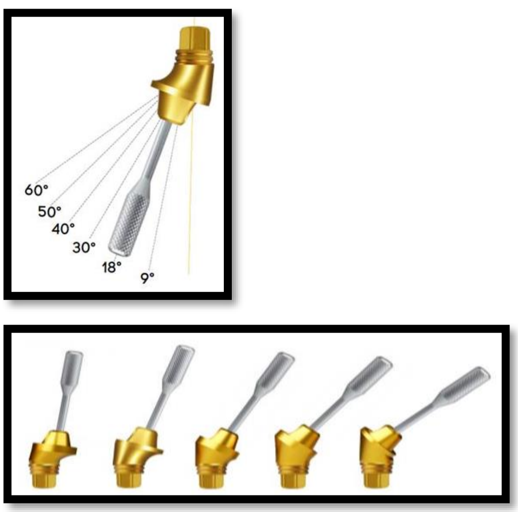

Figure 2: MUA with different angulations and collar heights

The Screw Physics:

MUAs are composed of two screw channels and it is important to understand the mechanism and properties of the screws used. This screw joint physics is explained in brief as follows:

a) Torque and Preload:

A screw joint is formed when two parts such as the implant and abutment are tightened together by a screw. The force applied to tighten the screw is called Torque and the applied torque generates a force within the screw which is called the Preload.

When the abutment screw is tightened, it elongates, creating a tension within its body. The elastic recovery of the screw pulls the two parts (abutment and implant fixture) together creating a Clamping force.[13] The force opposing this is called the Joint Separating Force. Such intraoral separating forces may include off-axis occlusal contacts, lateral excursive contacts, interproximal contacts between natural teeth and implant restorations, protrusive contacts, parafunctional forces, and non-passive frameworks that attach to the implants.[14]

Screw loosening occurs when the joint separating forces are greater than the clamping force. The preload in the screw is equal in magnitude to the clamping force and proportional to the applied torque. Therefore, increasing the torque increases the preload which increases the clamping force threshold and enhances joint stability to prevent screw loosening.[15]

If the applied torque is too small, it may allow separation of the joint and result in screw fatigue failure or loosening. If the applied torque is too large, it may cause failure of the screw or stripping of the screw threads. McGlumphy et al[16] stated that the optimal torque value is 75% of the torque needed to cause screw failure.

An important factor affecting the torque application is the method of applying torque (tightening the screw). Torque can be applied manually or with a mechanical device. The quality and consistency of the torque delivered is dependent on the accuracy of different devices and different operators.[17] Hence, proper training of the clinician and appropriate calibration of the torque wrenches/drivers should be achieved to minimize any discrepancy.

b) Settling effect:

When a screw is inserted to hold/clamp two parts together, screw threads by virtue of not being machined perfectly smooth, leave some rough spots leading to flattening of those irregular surfaces under load. Since initially they are the only contacting surfaces, some of the initial tightening torque applied to the screw is lost to smoothen irregularities in screw threads and abutment threads, causing a reduction in preload. This is termed as settling of the screw or embedment relaxation. It has been reported in the literature that 2% to 10% of the initial preload is lost as a result of settling.[18] Therefore, the torque needed to remove the screw is less than the torque initially used to place the screw.[15]

This problem can be tackled through the practice of Retightening the abutment screw. It has been recommended that retightening the abutment screw after 10 minutes with the tightening value higher than 30 Ncm would help in increased abutment screw joint stability and will reduce screw loosening.[19-21]

Another consideration that should be taken note of is the number of times the screw is tightened. Guzaitis et al.[22] in their study mentioned that 9 or fewer insertion cycles resulted in significantly greater mean reverse torque. After 10 screw insertion cycles, a new prosthetic screw should be used with the implant system to maximize screw reverse torque and maintain preload when an abutment is definitively placed.[22,23]

Biomechanical aspects of MUA:

1. Stress distribution

The principal concept in MUAs is to turn the internal connection into an external connection. Basically, it is an angle-changing abutment that acts as a spacer to go through the gums.[11] The prosthetic connection in MUAs is not at the implant-abutment joint, unlike the conventional straight and angulated abutments, because of the provision of a different prosthetic screw channel in their structure. Therefore, the MUAs act as stress-breaker and reduce direct stresses from the prosthesis on the crestal bone, thereby reducing crestal bone loss.[24]

Also, since these abutments aid in splinting multiple implants, they facilitate an even stress distribution pattern, reducing stress concentration on individual implants.[25] The angulation correction offered by MUAs dissipates the occlusal stresses in a more favourable manner and increases the longevity and stability of implant-supported restorations.

2. Reduced prosthetic cantilever

MUAs can correct for implant angulation and hence allow placement of tall tilted implants posteriorly. The tilting increases the antero-posterior spread and allows for prosthetic rehabilitation more posteriorly. Cantilevers are therefore reduced, improving support for the prosthesis.[26]

3. Passive fit through prosthetic platform correction

It has been mentioned in the literature that opposing surfaces of the implants and the prosthetic framework intaglio should be in maximum spatial congruency to achieve a passive fit. This is facilitated by the angulation and collar height correction offered by the MUAs.[27]

Also, the MUAs are shaped like a cone. If one cone is in alignment with another cone a bridge can be made over it, such that it will not rock from side to side, creating passive fitting of the prosthesis.[28]

MUAs also ease delivery of the restoration by raising the implant connection close to the gingival surface.[3] This prosthetic platform correction facilitates easy insertion of screw-retained restorations and creates a more predictable seating of the final restoration while making it easier for the dentist and lab-technician to work on the prosthetic superstructure.

4. Improved implant - bone interface stability

MUAs contribute to a better implant-bone interface environment due to the avoidance of stress concentration on individual implants. The raised prosthetic connection helps to avoid crestal bone stresses at the implant-abutment junction. This promotes successful osseointegration, better soft tissue profile, and increased overall stability of the implant-retained prosthesis.[24]

5. Increased bone-implant contact

The placement of taller tilted implants is facilitated because of the use of MUAs, thereby helping to maximize the bone-to-implant contact. They also encourage bicortical fixation improving primary stability and overall preserving the height of crestal bone to minimize crestal bone loss.[29,30]

Clinical applications of MUA

1. Implant angulation corrections and bypass of important anatomical structures

The design of MUAs aids in the correction of implant angulations. This allows the placement of tilted implants which avoids anatomical structures such as mandibular nerve, mental foramen, and the maxillary sinus. It also eliminates the need for bone augmentation.[11]

2. Multiple teeth/Full arch/full mouth rehabilitation

MUAs are available with varying angles and heights which permit selection of different abutments for multiple implants in the same arch to achieve parallelism among the differently angled implants. By splinting these multiple implants, stability and support can be provided to the full arch prosthesis.[27] In addition, the prosthetic workflow is simplified, and screw-retained restorations with great predictability can be achieved. This helps to avoid the peri-implant complications associated with residual cement in cement-retained prosthesis.

3. Esthetic zone rehabilitation

The emergence profile and soft tissue contours can be customized with the use of MUAs. This facilitates enhanced esthetic outcome resulting in natural looking and harmonious integration of esthetic and functional systems.[31]

4. Immediate loading

MUAs act as an interim connection between the prosthetic superstructure and the implant fixture so direct loads are not transmitted to the implant body through implant-abutment junction. This combined with angulation correction and prosthetic platform levelling aids in predictable immediate loading of implants.[30,31]

MUAs also follow the 'one abutment at one time' rule and are placed during surgery as they facilitate all prosthetic connections and disconnections above the implant level. This helps in developing a better soft and hard tissue profile.[32]

5. Simplified prosthetic procedures

The use of prefabricated components like MUAs reduces the need for complex laboratory procedures and chairside adjustments, saving valuable time and resources. The milling or casting of abutments to accommodate for different angulations can be avoided since parallelism can be achieved through MUAs.[31]

6. Preservation of biologic width

The varying angles and collar heights of MUAs convert the working platform to a supragingival level where the sensitive subgingival connection of implant-abutment is not disturbed time and again by repeated removal and placement of abutments. This helps to preserve the biologic width and also permits easy maintenance of peri-implant tissues.[26]

MUAs have a platform-switched implant-abutment connection. This presence of a non-matching, smaller diameter abutment platform assists in moving the implant–abutment micro gap with its inflammatory cell infiltrate away from the stress concentration zone of crestal bone along the long axis of the implant fixture.[33]

7. Better soft and hard tissue profile

As mentioned earlier, MUAs follow the "one abutment at one time" protocol. They are placed intraoperatively and do not require multiple screwing/unscrewing of the abutment since all prosthetic superstructure is attached through a separate prosthetic screw channel. All manipulations happen above the bone level and implant platform which encourages better hemidesmosomal adherence between the soft tissue and titanium and therefore might reduce bone resorption around the implants. This is especially advantageous in immediately restored implants for partial and full edentulous cases.[34,35]

Modification of MUA

In a recent development, there is an iMultiunit design system from Bioline which is now in use with the implants placed through the TTPHIL: ALL TILT® protocol.[36] This system has made several modifications to the conventional design of MUAs to overcome their present limitations and yield better results.

These iMultiunit abutments have microgrooves (1mm and 3mm) on their neck for better engagement of peri-implant hard and soft tissues. (Figure 3) This "Mucolock connection" aids in achieving a better emergence profile and increased soft tissue thickness.

In the literature, histological assessment of grooved abutments has revealed that inter-implant gingival fibers between grooved abutments appeared to be more numerous and organized, compared to standard abutments. The connective tissue thickness from implant shoulder to gingival margin (IS-GM) and implant shoulder to junctional epithelium (IS-JE) in grooved abutment-implant was greater than corresponding distances in standard abutment-implant , while crestal bone loss (IS-BC) was lesser for grooved abutment-implants than standard abutment-implant. Therefore, the modified groove design abutments conferred both soft and hard tissue benefits.[37]

These abutments by virtue of their platform-switched design and those microgrooves, also assisted in maintaining biologic width and in achieving a biolock connection to prevent bacterial infiltration due to their long internal hex design (1.8mm). The same feature can be attributed to better and more contact area between the screw and abutment, since these abutments are longer and can be engaged at greater subcrestal depth, thus minimizing the chances of screw loosening.

The BioLine's iMultiunit 2 screw Tissue Level Abutment System is indicated for multiple-unit, screw-retained restorations, and may be used in combination with an implant-level framework design. It aids in elevating the seating platform of restoration when the restoration at implant level is not indicated or practical due to the depth or angle of the implant.

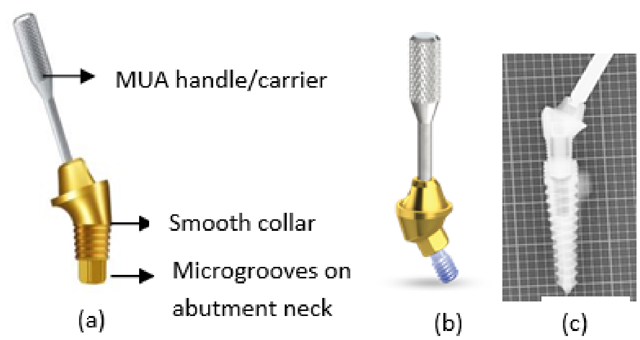

Figure 3: (a) iMultiunit abutment with longer design and microgrooves, and (b) Standard MUA (c) Radiographic view of iMultiunit with 3mm microgrooves

Placement of MUAs

1. The MUA is placed over the implant by using the pre-mounted abutment holder. (Figure 3) Based on the depth of the implant subcrestally placed, an appropriate collar height of the abutment is chosen.
2. The abutment is screwed into the implant with a prosthetic screwdriver until a resistance is felt, but it is not tightened completely at this stage. A radiograph is taken to confirm the seating within the implant fixture.

3. Once it is deemed accurate, the holder is unscrewed from the abutment by turning it counterclockwise.
4. Final tightening of the abutment is done according to manufacturer's instructions.
5. Prosthetic components can then be attached over the MUA for taking impressions (manual or digital) with the corresponding attachment of lab analogs.
6. While the prosthesis is being fabricated, a temporary restoration or healing cap is connected at the MUA.

Limitations of MUA

It has been argued in the literature that MUAs have quite a short tightening screw which can make it difficult to tighten the abutment sufficiently and cause screw loosening.[3] However, studies have shown that increasing the diameter and the length of the screws can easily overcome this issue.[38] iMultiunit abutments are one example of the design that can overcome this limitation. Also, screw loosening is commonly associated with the lack of passivity of the prosthetic superstructure, which is conveniently avoided by use of MUAs.[27,28]

MUAs cannot be used with limited interocclusal space because of the addition of an extra component and they are not deemed feasible for single tooth restorations.

Another limitation of MUAs is that their manoeuvring can be a little difficult for the clinicians in the mouth of the patients. These abutments require a unique handle for placing the abutment on top of the implant, to provide easy and secure handling for simple insertion and optimal base placement into the implant (Figure 3). This unit might not be available in some implant systems or may be one more additional cost for the dentist and dental technicians.[11]

Also, some clinicians might have difficulty in determining the angulation correction in the patient's mouth. Two simple techniques for judging the angulation of the MUAs and avoiding errors in their selection chairside have been discussed in the literature.[39] Proper technique and sound knowledge regarding these can be of great help to the practitioner.

Future directions of MUAs

MUAs have revolutionized the restorative phase of implant treatment. With continuous evolution, there are several promising directions for their future development and utilization.

1. Digitalization

CAD CAM technology compiled with digital impressions, virtual planning, and 3D printing can enable precise implant positioning and prosthetic design to facilitate optimal outcomes with MUAs. Also, the utilization of intraoral scanners, virtual articulators, and advanced software can enable precise and efficient lab communication while easing the clinical methods for patients.[27,40]

2. Material advancement

Although the biocompatibility and strength of titanium is working well with MUAs, researchers are exploring the use of novel materials like zirconia, titanium alloys, and ceramic-based materials to improve the aesthetic and biomechanical properties of MUAs. These materials are being explored with the intention of overcoming the demerits of the present materials.[41]

3. Biomechanical optimization

FEA and biomechanical studies can provide insights into load distribution, stress patterns, and the effect of different designs on implant and bone health. This data can aid in predicting the effects of different designs and dimensions of MUAs for further enhancement of their biomechanical performance.[24]

Conclusion

Within the limitations of this review, MUAs appear to be an emerging viable alternative for the restoration of multiple implants with screw-retained immediately loaded prostheses. The passivity, implant angulation correction, ease of prosthesis fabrication due to prosthetic level correction, better attachment of hard and soft tissues, improved emergence profile, and freedom of placing long titled implants to bypass anatomical structures without the need for additional surgical procedures of grafting, all make MUAs the abutments of choice for prosthetic rehabilitation of implants. Careful consideration of the recommended protocols and continuous evolution of research and innovation, can further enhance the esthetic and functional outcomes in implant dentistry with these abutments.

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