



Comparative study between two different designs of four implants placement supporting mandibular overdenture: Review article

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ABSTRACT

Edentulous patients are often associated with decreased in the masticatory function, loss in vertical dimension, speech impairment and poor esthetics due to loss in facial musculature support. The traditional way for treating edentulous patients is a complete removable denture. However, the progressive tissue changes occur due to wearing the denture should be compensated by denture adjustment. In completely edentulous patients the implant supported overdentures is a common treatment plan which could improve oral function and comfort for edentulous patients. The concept of rehabilitation of full arch on four implants is a useful therapy in the treatment of an edentulous patient. The quadrilateral design showed enhanced results in regard to survival and success rate and minimal strain compared to curved (three implants) or linear (two implants) designs. Tilting the distal implant giving us various advantages as the implant reach a more posterior position so the length of the cantilever is reduced. Also it preserves related vital structures, avoid bone grafting and allows using longer implants that increases the implant primary stability due to increased implant-to-bone contact area, increases the inter-implant space, lead to better load distribution. The rehabilitation of edentulous mandible with telescopic overdenture supported by four parallel implants was a successful treatment option however, tilting the posterior implants 30 degree distally might present a several advantages regarding the increased anteroposterior spread which in turn decrease the load transmitted to the implant.

Keywords: *Implants, Overdenture, Inclined, Radiographic*

1. Review of Literature

1.1. Problems with removable dentures

Edentulism, according to the Glossary of Prosthodontic Terms, is defined as the complete loss of all dentition. It is an irreversible condition that is evident in older patients, and was previously considered part of the normal aging process. Loss of alveolar bone occur continuously with time making the stable dentures ill-fitted and the patients always having problems with their conventional dentures because of decrease in there masticatory action, impairment of the motor control of the tongue, decrease in bite force and weakened oral sensory function, also the lower complete dentures having stability and retention problems as a result of the smaller denture bearing areas which affects the chewing ability.(Felton et al., 2011) These factors cause a lot of problems such as pain which related to movement of the denture during mastication, laughing or speaking leaving fears about the negative image of dentures in social situations.("The Glossary of Prosthodontic Terms: Ninth Edition," 2017; Lee & Saponaro, 2019)

1.2. Implant overdenture

Implants affect oral motor functions which improving occlusal stability and support which reflected by occlusal force and chewing efficiency, compared with a conventional complete denture, the masticatory efficiency with Implant supported overdenture is improved as well as improved harmony of mandibular movement patterns.(Leao, Moraes, Vasconcelos, Lemos, & Pellizzer, 2018) The tongue and perioral musculature become in a more normal position as the implant supported overdenture become stable during mandibular movements, which provide better results in patient phonetics. Also it has an important advantage for the new denture wearers or those who have low gagging thresholds as the implant overdenture may reduce the extent of soft tissue coverage, also elimination of too much labial contours for the patient with recent extractions as there is no need for a labial flange.(Martinez-Lage-Azorin, Segura-Andres, Faus-Lopez, & Agustin-Panadero, 2013)

However, implant survival may be attributed to multiple factors as bone quantity and quality, number, implants length and diameter, primary stability, implants distribution across the arch, implant surface and geometry, loading protocol, maintenance of oral hygiene, prosthetic design and occlusal concept.(Artzi et al., 2010)

1.3. Treatment Options

The utilization of dental implants, as a means for improving retention, has become a common and effective procedure in the last decades. Various authors have presented data on overdentures supported by 1-8 implants. Several attempts were made to find an answer to the question of how many implants should be used to retain/support an overdenture.(Rocuzzo, Bonino, Gaudio, Zwahlen, & Meijer, 2012) Different forms of prostheses have been reported for fully edentulous patients. Of these; fixed implant-supported prostheses and removable implant-supported prostheses.(Emami, de Souza, Bernier, Rompre, & Feine, 2015; Preciado, Del Rio, Lynch, & Castillo-Oyague, 2013)

1.4. Fixed implant-supported Prostheses

Patient's desire is the primary disadvantage of the overdenture, some patients seeking a fixed prosthesis primarily to satisfy their psychological need and feel that the prosthesis is a part of their body. In addition to lack of inter-arch space makes an overdenture system more difficult to fabricate.(Goodacre & Goodacre, 2017) Also, in a study by Feine et al., (Feine et al., 1994) where patients were randomly divided into two groups. One group received the fixed implant-supported prostheses first, while the other first received the removable implant-supported prostheses. After a two-month adaptation period doing all the tests, the prostheses were then changed, and the procedures repeated. At the end of the study, patients choose the prosthesis they wished to keep. Both groups rated the fixed as significantly better in respect to stability and ability to chew than with the removable. However, the removable group rated ease of cleaning as the most important factor governing their decision, followed by esthetics and stability. The Fixed group considered stability to be the most important factor in their decision, followed by chewing ability and ability to clean. Older subjects had a tendency to choose the removable prosthesis. From these results, it was suggested that patients choose fixed or removable implant-supported prostheses for specific reasons, and that patient attitude should be considered when the design of a prosthesis is being planned for an individual patient. The fixed implant-supported prostheses are expensive treatments due to the complexity of surgical and prosthetic phases, cost of implants and prosthetic components and laboratory fees. The overdenture is an alternative to fixed implant-supported prosthesis for its relatively low cost. It is also indicated in cases of impossibility of placing multiple implants with appropriate number and arrangement in the arch to support a fixed prosthesis due to anatomic factors.(Mariano et al., 2012)

1.5. Removable implant-supported Prostheses

For the removable implant supported prosthesis, it is well known that implant overdentures reduce the rate of resorption of the anterior ridge with increasing denture retention and stability.(Gul, 2014) Compared to fixed implant supported prosthesis, the overdenture allows easier cleaning as they are removable and supported by fewer number of implants.(Mariano et al., 2012) The removable implant supported prosthesis might be considered a better treatment option to fixed implant supported prosthesis in patients with excessive ridge resorption which has led to the loss of facial support of the lips and soft tissues of the face as a result of severe residual ridge resorption and when inadequate accessibility to maintain good oral hygiene.(Awaad, Eladl, & Abbass, 2019; Lavery, Green, Marrison, Addy, & Thomas, 2017) The York statement concluded that patient satisfaction and quality of life with implant supported mandibular overdentures is significantly greater than for conventional dentures. (Thomason et al., 2009) The McGill consensus statement in 2002 and some studies (Harris et al., 2013; Krennmair, Seemann, Fazekas, Ewers, & Piehslinger, 2012) state that mandibular two-implant overdentures are minimum treatment care for edentulous patients, however, technical and biological complications may occur.(French & Tallarico, 2014) The study of Thomason et al., (Thomason, Kelly, Bendkowski, & Ellis, 2012) aimed to present the current evidence and rationale to support the McGill and York consensus statements. The conclusion was that a two-implant overdenture should become the first choice of treatment for the edentulous mandible. However, overdentures assisted only by two anterior implants have some limitations, as they share the posterior edentulous ridge in support. This might cause poor implant support, stability and decrease in occlusal force and increased bone loss in the posterior edentulous regions. This is due to undue stresses transmitted from rotation of the denture base around the anterior implants as in class one partial edentulous cases which demand an increase in prosthetic maintenance appointments due to wear of the attachments and the need for relining.(Osama M. Askar & Emera, 2016) The use of three implants with this specific tripod distribution to support a mandibular overdenture offer several advantages compared to a proposed standard treatment with a mandibular two implant overdenture. The anterior- posterior spread of the three implants over the ridge limits the rotational movement inherent to mandibular two implant overdenture. This rotational movement has been associated with patient discomfort, reduced chewing ability, and significant dissatisfaction with mandibular two implant overdenture treatment.(Alsabeeha, Ma, & Payne, 2022) Moreover, increased resorption of the posterior mandibular ridge in edentulous adults wearing mandibular two implant overdentures has also been demonstrated. With the three implant overdenture design, the presence of the posterior implants could reduce excessive stresses and reduce posterior residual ridge resorption.(Alsabeeha et al., 2022) Depending on implant supported overdenture support, we may classify them in: a) Implant retained and mucous supported overdentures, if the denture is supported by tissues and are retained on the implants, and b) Implant retained and supported overdenture, if support and retention are due to the implants that behave as a fixed denture but can be removed for an adequate oral hygiene.(Martinez-Lage-Azorin et al., 2013) Implant supported overdenture is indicated for patient with sensitive mucosa which is easily irritated by the pressure of a denture, when bone is resorbed and mental nerve is exposed, when knife edge ridge or sharp myelohyoid ridge is present and in patients with extreme gag reflex.(Rohit Sharma, Alok Kumar, Devendra Chopra, & Tewari, 2014) Clinical investigations and implant load analyses encourage the treatment of full-arch fixed prostheses by using only four implants rather than six implants.(Zhang et al., 2023) It was stated that mandibular overdentures supported by four implants placed in the positions of the canines and molars improve and simplify anchorage systems based on conical copings. They added that the prosthesis stability results in psychologic comfort and masticatory performance similar to that of fixed prostheses but with hygienic, esthetic,

and cost advantages.(MA, Elsaadawy, Abdou, & Habib, 2013) Fully implant-supported prosthesis including four or more implant supporting the prosthesis receives support directly from the superstructure connected to the implants. Additionally, it provides resistance to rotational and lateral forces. During mastication, the attachment assembly transfers all of the masticatory forces to the supporting implants.(Gul, 2014) The rigid anchoring creates a stable occlusal plane and prosthesis position reducing possible jaw resorption and decreases the incidence of prosthodontic maintenance of removable implant prostheses as described by Weinlander et al., (Weinländer, Piehslinger, & Krennmair, 2010)

1.6. Problems of posterior implant placement

The rehabilitation of severely atrophic mandible using implant-supported prosthesis is often challenging because of the poor quality and quantity of residual jawbone. That's especially true for patients with long-term due to Progressive bone loss in the posterior mandible may lead to a superficialization of the alveolar nerve. This might render pain to denture wearers during mastication. In such case, the placement of implants, even though of short length, in the posterior regions of the mandible may be challenging.(Ozan & Kurtulmus-Yilmaz, 2018) Many attempts could be considered a solution for facilitating implant placement in the posterior mandible such as bone augmentation procedures however, these types of intervention are poorly accepted by patients.(Ozan & Kurtulmus-Yilmaz, 2018) Transpositioning of the mandibular nerve is one possibility for placing long and stable implants in the molar region but problems with paresthesia of the mental nerve have been reported.(Abayev & Juodzbaly, 2015) Another technique is to place short implants above the mandibular canal. The use of short-length implants allows treatment of patients who are unable to undergo complex surgical techniques for medical, anatomic or financial reasons. Moreover, the use of short-length implants in daily clinical practice reduces the need for complex surgeries, thus reducing morbidity, cost and treatment time. Nisad et al.,(Nisand & Renouard, 2014) concluded that short-length implants can be successfully used to support single and multiple fixed reconstructions in posterior atrophied jaws, even in those with increased crown-to-implant ratios. However short implants are reported to fail more frequently than longer ones. In an atrophied completely edentulous arch, the implants are placed in a fairly upright position anterior to the mental foramen. Consequently, it is often necessary to fabricate a bilateral cantilever so as to provide the patient with good chewing capacity in molar regions.(Ozan & Kurtulmus-Yilmaz, 2018) The use of cantilevered implant-supported fixed dental prostheses has been suggested as an alternative in posterior regions where placing additional implants represents a challenge due to lack of bone height and/or width. Distal cantilevers may reduce the healing time and treatment costs. However, the biomechanical performance of implant-supported rehabilitations with cantilevers has been associated with low survival rates and frequent biologic and technical complications.(Hinze, Thalmair, Bolz, & Wachtel, 2010; Malo, de Araujo Nobre, & Lopes, 2013) The use of distal cantilevers in the absence of posterior implants has been proposed with survival rates ranging between 50% to 100%.(Romanos, Gupta, & Eckert, 2012) Romanos et al.,(Romanos, Gupta, Gaertner, & Nentwig, 2014) assessed the clinical success of distal cantilevers of fixed full-arch prostheses in conjunction with immediate loading implants, thus obtaining an implant success rate of 94.5%, an implant survival rate of 97.5%, and a prosthetic survival rate of 96.7% at five years. Malo et al.,(Malo, de Araujo Nobre, et al., 2013) analyzed the outcome of implant-supported fixed dental prostheses with cantilevers after 5 years of prosthetic loading. The incidence of biological and mechanical complications in their investigation were 2.9% and 27.6%, respectively. Nonetheless, they registered a success rate of 99% and concluded that, despite the relatively high frequency of complications encountered, a fixed implant-supported partial rehabilitation with cantilever may

be a viable treatment option. According to the intuitive concepts, dental implants must be placed in the axial plane to achieve and sustain adequate osseointegration. The primitive concept advocated the use of implant placement that was “in-line” or perpendicular to occlusal stresses and claimed that tilted implants would lose bone and eventually “de-osseointegrate”.(Mehta et al., 2021) However, another technique for treating atrophic edentulous maxilla using titled implants was discovered to be a possible therapeutic option because of technological advancements.(Morton et al., 2018) Its goal was to get maximum cortical bone involved for support.(Nag & Bhagwatkar, 2020) It has several advantages, including strong primary stability even with low bone volume, longer implant length for more bone to implant contact, more anterior-posterior spread, reducing cantilever length, an optimal load distribution may be achieved, minimally invasive approach without bone grafting, and ability to place implants close to anatomical structures.(Asawa, Bulbule, Kakade, & Shah, 2015; Barnea et al., 2016) Nonetheless, it has been assumed that the use of tilted implants could negatively affect the treatment outcomes due to the presence of unfavorable forces applied to the peri-implant alveolar bone. It was found that tilting the distal implant did not affect marginal bone level changes after 24 months follow up.(Menendez-Collar et al., 2018) In a study carried out by Hinze et al.,(Hinze, Thalmair, Bolz, et al., 2010) in patients who underwent treatment with either mandibular or maxillary full-arch fixed prostheses supported by two axially inclined and two tilted implants, the 1-year implant survival rates were 96.0% for axially positioned implants and 94.6% for tilted fixations; so that no significant differences were encountered among both types of implants. The combined use of axially placed and tilted implants represents another possible alternative for the treatment of edentulous jaws, which has been extensively documented in the recent years.(Patzelt, Bahat, Reynolds, & Strub, 2014) At the same time, the adoption of longer implants and a proper insertion axis may allow engagement of as much cortical bone as possible, favoring the achievement of adequate primary stability of the implants.(Del Fabbro & Ceresoli, 2014) On the other hand, unfavorable loading direction could in theory induce greater bone resorption around tilted implants as compared to axially placed ones, as suggested by other in vitro studies that reported accentuated stresses around non-axially placed implant necks.(Lan, Pan, Lee, Huang, & Wang, 2010) Excellent clinical results of rehabilitations supported by a combination of axial and tilted implants have been reported, with high implant survival and prosthesis success rates, and a high level of satisfaction for the patients, in spite of a relatively high incidence of biomechanical complications.(E. Agliardi, Panigatti, Clerico, Villa, & Malo, 2010) The latter could be generally managed at chairside.(Patzelt et al., 2014) The use of tilted implants (placed distally mesial to the mental foramen nerve) has been proposed by several authors within the past decade as a viable treatment option for the prosthetic rehabilitation of the severely atrophic posterior jaws, their advantages include a greater anchorage of the implant to the cortical plate as well as the possibility to avoid vital anatomical structures also the implant reach a more posterior position so the length of the cantilever is reduced.(Menendez-Collar et al., 2018) Findings from clinical studies comparing both tilted and axially placed implants show similar success rates, and marginal bone loss for either type of implant.(Mehta et al., 2021) It was reported that there are several surgical and prosthetic advantages in tilting posterior implants, representing a viable alternative to grafting. Therefore, partial or total immediate restorations over tilted and axial implants reported high percentage of survival rates.(Kim, Kim, Bae, & Cho, 2011) Also it allows using longer implants that increases the implant primary stability due to increased implant-to-bone contact area, increases the inter-implant space, lead to better load distribution, no need for bone augmentation as it maximizes the use of available bone.(Del Fabbro, Bellini, Romeo, & Francetti, 2012) In a two-dimensional finite element analysis, it was observed that distal tilting of implants which splinted in a fixed

restoration did not increase the stress transmitted to the marginal bone as compared to axial implants. (Almeida et al., 2015) Also using tilted distal implants rather than distal cantilever units has proven biomechanical advantage. (Mehta et al., 2021; Pancko, Dyer, Weisglass, & Kraut, 2010) Compared to previous grafting treatments, this philosophy of placing implants in preexisting bone applied the therapeutic idea of taking maximum advantage of the naturally available bone, resulting in a simple, more predictable, less expensive, and faster rehabilitation. (Mehta et al., 2021) Several studies (E. L. Agliardi et al., 2014; Agnini et al., 2014; Cavalli et al., 2012; Francetti, Romeo, Corbella, Taschieri, & Del Fabbro, 2012; Lopes, Malo, de Araujo Nobre, & Sanchez-Fernandez, 2015; Malo, Nobre, & Lopes, 2013) observed angulation angles ranging from 30° to 45° degrees. According to Roberto Crespi et al., (Crespi, Vinci, Cappare, Romanos, & Gherlone, 2012) the degree of angulation for a distally inclined implant is between 30° and 35°. However, according to Luca Francetti et al., (Francetti et al., 2012) and Browaeys et al., (Browaeys et al., 2015) might be up to 30°. Implant inclination may be carefully planned by the surgeon in order to avoid damage to important anatomical structures. Besides, with proper implant length and insertion axis, primary stability of the implants may be achieved, allowing immediate rehabilitation. (Weinstein, Agliardi, Fabbro, Romeo, & Francetti, 2012) In a study by Bevilacqua M et al., (Bevilacqua et al., 2011) tilted distal implants, rigidly splinted with a fixed prosthesis was found to decrease peri-implant bone stresses as compared to a vertical implant model with cantilevered segments. Zampelis et al., (Zampelis, Rangert, & Heijl, 2007) elaborated similar conclusions in a 2-dimensional study, reporting that peri-implant bone stresses at the most coronal bone-implant contact point were reduced when cantilever segments were eliminated and the distal implants were inclined distally to support the distal end of the cantilevers. The cantilever length reduction associated with the fixed dental prosthesis design involving tilted implants probably had a key role in decreasing peri-implant stresses around the implants.

1.7. Peri-implant marginal bone loss around tilted implants

The placement of tilted implants offers both surgical and prosthodontic advantages. Actually, the combination of tilted and axial implants allows for the use of longer implants (thereby increasing the osseointegration surface); improves the primary stability by anchoring in more than one cortical layer; decrease cantilever extensions by placing the implants more distal and with a more optimal load distribution over the dental arch; and avoids the use of bone grafts and sinus lift procedures (with the resulting reduction in technique morbidity). Nonetheless, it has been assumed that the use of tilted implants could negatively affect the treatment outcomes due to the presence of unfavorable forces applied to the peri-implant alveolar bone. In their study, tilting the distal implant did not affect marginal bone level changes after 24 months follow up. (Ata-Ali, Penarrocha-Oltra, Candel-Marti, & Penarrocha-Diago, 2012; Menendez-Collar et al., 2018) A study involved a follow-up of 12 months, demonstrated high implant survival rates rehabilitating patients with implant-supported immediately loaded fixed full-arch dentures based on four implants including tilted implants. (Hinze, Thalmair, & Bolz, 2010; Niedermaier et al., 2017) Francetti (Francetti et al., 2012) found similar results when analyzing the clinical outcomes about the changes of peri-implant bone level around tilted and axial implants supporting full-arch fixed immediate rehabilitations up to 60 months of loading. No significant differences in marginal bone loss were identified between axial and tilted implants in both jaws concluding that the use of tilted implants in the immediate rehabilitation of fully edentulous jaws is safe and is not associated to a higher marginal bone loss as compared to axially placed implants. In a study by Neidermaier et al., (Niedermaier et al., 2017) it was found that survival rates of axial and tilted implants reached 98.5% and 96.0%. So tilting of implants reduces

the length of the cantilever and thus, reduces the mechanical stress on the prosthesis. Fazi et al., (Fazi, Tellini, Vangi, & Branchi, 2011) reported that when comparing several implant numbers and positions, the use of the tilted implants reduce the load transmitted to the bone. In this issue, another prospective study by Meloni et al., (Meloni, Tallarico, Pisano, Xhanari, & Canullo, 2017) evaluating the 5-year clinical and radiographic outcomes of immediately loaded implants (using axial and tilted placements). They concluded that the overall 5-year mean marginal bone loss was 1.6 mm, demonstrating well maintained marginal bone level. According to the study of Lopes et al., (Lopes, Malo, de Araujo Nobre, Sanchez-Fernandez, & Gravito, 2017) that evaluated the long term outcome of the full-arch flapless rehabilitations. They elaborated that the average marginal bone loss was 1.30 mm at 5 years, with 1.27 mm for tilted implants and 1.33 mm for axial implants. Taking into consideration the marginal bone loss after 5 years of follow-up, the present study registered a significant difference between axial and tilted implants. In this sense, and despite the statistical significant difference, the difference during 5 years was considered negligible from a clinical point of view. In contrary to these findings about peri-implant bone loss in the All-on-four protocol, a study by Browaeys et al., (Browaeys et al., 2015) have reported that after 3 years of follow up for marginal bone loss around prostheses, they found that there was no significant difference for marginal bone loss was found between axially and tilted placed implant in all the patients. Alessandro Pozzi et al., (Pozzi, Tallarico, & Moy, 2016) conducted a study about peri-implant bone loss of a four implants overdenture for the rehabilitation of the edentulous maxilla and mandible. It was found that slight marginal bone loss was reported after 1 year in function.

Disclosure

The author reports no conflicts of interest in this work.

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