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Original Research Article

Maxillary Overdenture Implant Survival Rate and Prosthetic Complications: An Observational Study

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Abstract: ***Background:*** Edentulism is a serious public health problem since it is a physical defect that has been associated with significant impairments in self-esteem, communication, nutrition, and perceptions of appearance. This study aimed to evaluate the survival rate and prosthetic complications of implant-supported overdentures in the edentulous upper jaw. ***Methods:*** This prospective study was carried out at Banasree Dental and German Dental implant surgery centers from December 2011 to December 2021 where 78 patients were included in this study and evaluated clinically and radiographically. A total of 20 patients were excluded as they did not agree to or maintain the follow-up schedule. After this procedure, 58 patients (24 male and 34 female) were evaluated for this study. ***Results:*** The mean age of the patients was 61.3± 6.8 years whereas the 24 (41.4%) were male. The total survival rate of implants was 94.8% at the 5-year follow-up and 92.2% at the 10-year follow-up. In the 3.0 mm diameter implants, the lowest survival rate was 70.6% at the 5-year follow-up and 52.9% at the 10-year follow-up, whereas in the 3.8 mm diameter implants it was 95.1% and 93.4%, in the 4.2 mm diameter implants it was 97.8% and 96.7%, and in the 4.6 mm diameter implants it was 94.8% and 92.2%, respectively. Most of the 29 implants had prosthetic tooth fractures, followed by 18 premature wear of gaskets, 15 prosthesis loosening/shedding, 9 damaged prosthesis flanges, 4 damaged baskets, and 3 implants with screw loosening. ***Conclusion:*** It is concluded that implant-supported maxillary overdentures have a high rate of survival and are a safe and reliable treatment option. But it's obvious that biological and mechanical complications arise frequently and that they become more common over time.

Keywords: Overdenture, Maxilla, Implant for smokers, Prosthetic Complications, Dental Implant, Survival Rate.

INTRODUCTION

Edentulism is a serious public health problem since it is a physical defect that has been associated with significant impairments in self-esteem, communication, nutrition, and perceptions of appearance. Complete dentures have traditionally been used to treat fully edentulous patients. However, because of progressive maxillary bone loss, these patients frequently struggle to chew and experience poor prosthetic retention, which has a negative impact on their quality of life in terms of oral health [1, 2]. The installation of dental implants to hold overdentures in the edentulous jaws can now successfully treat these problems [3]. An implant-supported overdenture has benefits such as improved chewing ability, comfort, and stability that lead to enhanced patient satisfaction and quality of life [3]. A removable dental prosthesis known as an

overdenture is supported by one or more natural teeth still present, their roots, and/or dental implants [4]. When it comes to treating edentulous individuals, implant-supported overdentures are regarded as a good therapeutic choice since they satisfy both functional and aesthetic needs [5–8].

Implant-supported mandibular overdentures have been the subject of numerous studies and systematic reviews, all of which have shown outstanding long-term results [9-11]. Only a few studies examined the mid-and long-term effectiveness of implant-supported maxillary overdentures [12, 13]. Additionally, maxillary implants supported overdentures have reported worse mid- and long-term implant survival/success rates [14–16]. These less favorable outcomes have been linked to bone volume and quality issues that are frequently more severe at maxillary than mandibular sites [14, 15]. The treatment outcomes of implant-supported maxillary overdentures, however, may be influenced by a variety of variables, including the kind, quantity, and positioning of fixtures as well as the loading circumstances [11, 14–16]. The minimal number of implants necessary for the edentulous maxilla to be sufficiently restored using a detachable partial overdenture has not yet been sufficiently investigated [17, 18]. The edentulous maxilla should have a minimum of four implants, according to the Fifth International Team for Implantology consensus statement from 2013 [19]. However, some research indicates that the use of two maxillary implants as opposed to four has no impact on patient satisfaction or mean bone support [20-22]. This study aimed to evaluate the survival rate and prosthetic complications of implant-supported overdentures in the edentulous upper jaw.

MATERIALS AND METHODOLOGY

This prospective study was carried out at Banasree Dental and German Dental implant surgery centers from December 2011 to December 2021 where 78 patients were included in this study and evaluated clinically and radiographically. A total of 20 patients were excluded as they did not agree to or maintain the follow-up schedule. After this procedure, 58 patients (24 male and 34 female) were evaluated for this study. Patients with edentulism in the maxilla, functional problems with the conventional complete maxillary denture, sufficient maxillary bone volume to place implants at least 5 mm in diameter and 8.0 mm in length, and good general health conditions were included in this study. The patients need bone augmentation procedures with autogenous bone and/or bone substitutes prior to implant insertion, uncontrolled diabetes mellitus, immunocompromised status, radiotherapy in the maxillofacial region, chemotherapy, treatment with amino-bisphosphonates, and clinical signs of severe oral functional disorders were excluded from this study. Smoking was not considered an exclusion criterion for this study; however, patients were advised that smoking is associated with an increased risk of implant failure. All participants received detailed explanations about the planned treatment and its potential risks and complications and signed a written informed consent form before being enrolled in the study.

Surgical and Prosthetic Procedures

At first patient and surgery room ware prepared for implant surgery with highest level of safety and sterility. Under local anaesthesia, the surgical procedure was carried out following the manufacturer's instructions. With implant drills of increasing diameter and continuous cooling, implant sites were prepared according to the protocol. At the level of the bone crest, the fittings were placed. Each maxilla that was missing teeth received at least two implants. The patients' entire dentures were then relined with a soft tissue conditioner and utilized as interim prostheses after the flaps were adjusted to completely cover the implants and fastened in place by interrupted sutures. Ice packs were made available after surgery. All patients got oral antibiotics for seven days, as well as medication to reduce postoperative pain and comprehensive oral hygiene instructions. For seven days, patients were required to follow a soft diet. Smokers were advised to abstain from smoking for 48 hours following surgery. Before going back for the second stage of surgery, all patients wore temporary complete dentures. Four months were spent with the implants submerged. Following this period of uninterrupted healing, a second step of surgery was performed to gain access to the underlying implants, and healing abutments were inserted. The ridge mucosa was raised to reveal the implants after a mesiodistal crestal incision was created that was restricted to the implant sites. The cover screws were then swapped out for healing abutments. The mucosal flap was repositioned to abut the healing area and then sutured in place. The full temporary dentures were then placed in the mouth and discharged liberally all around the healing abutments before undergoing another partial relining with a tissue conditioner. The healing abutments were taken out two weeks later, and pick-up impression posts were inserted at the implant level. Utilizing polyvinylsiloxane and generic trays, the final implant impression was created. The supra structures for the implants were ball titanium abutments, to which stainless-steel housing and silicon insert were attached. Each OD was made of acrylic resin. In

order to provide a balanced occlusion in centric relation without anterior tooth contact, all overdentures were meticulously examined for correct occlusion. Protrusion and laterotrusion were measured on the articulator and intraorally.

Follow-up

The follow-up period for patients after the delivery of the upper overdenture is between 60 and 120 months. The implant is considered 'survived' if its superstructures function normally when clinically evaluated. Pain on palpation, percussion, or function of the implant, any mobility of the implant, purulent exudate, uncontrolled progressive bone loss, removed or no longer the teeth in the mouth were considered 'failed' implants. Prosthetic complications, such as mechanical complications related to implant components (loosening or fracture of the abutment), and technical complications, including issues related to anchorage structure (broken balls or loose, lost, or broken attachments) or prostheses (repairs of fractured prostheses or overdenture teeth) were evaluated at the follow-up time.

SPSS Version 21.0, developed by SPSS Inc. in Chicago, Illinois, was used to analyze all of the data. Descriptive statistics were used for patient demographics (gender, age, and smoking habit) and the distribution of implants (position, diameter, and length). Frequency distributions were calculated for qualitative variables, such as implant survival or failure and prosthetic complications.

RESULTS

Table 1: Baseline Characteristics of Investigated Patients, (N=58)

Variables	Number	Percentage
Age (Mean± SD) yr	61.3± 6.8	
Gender		
Male	24	41.4%
Female	34	58.6%
Location		
Anterior	30	51.7%
Posterior	28	48.3%
General illnesses		
Diabetes mellitus	6	10.3%
Coronary heart disease	8	13.8%
Active smoker	9	15.5%

This table shows the baseline characteristics of the investigated patients, where the mean age of the patients was 61.3± 6.8 years and 24 (41.4%) were male. 30 (51.7%) of the patients' overdentures were anterior, while 28 (48.3%) were posterior. 6 (10.3%) patients had diabetes mellitus, 8 (13.8%) had coronary heart disease, and 9 (15.5%) patients were active smokers.

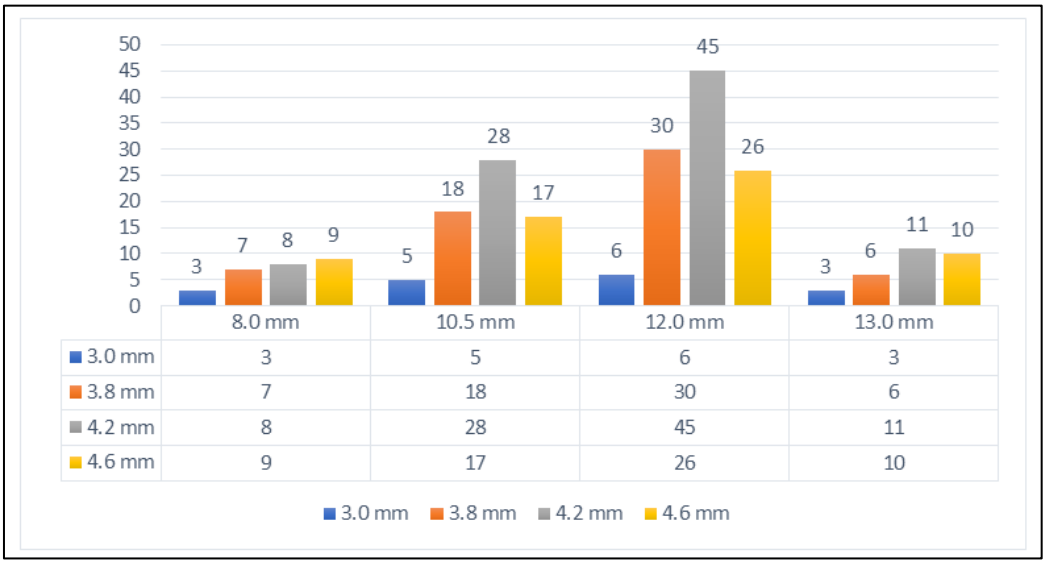

Figure 1: Distribution of the implants by length and diameter

There were 232 implants in the 58 patients where the most 45 implants were 4.2 mm in diameter and 12.0 mm in length, followed by 30 implants that were 3.8 mm in diameter and 12.0 mm in length, 28 implants that were 4.2 mm in diameter and 10.5 mm in length, 26 implants that were 4.6 mm in diameter and 12.0 mm in length, and a few implants that were 3.0 mm in diameter.

Table 2: Implant survival rate during 5 years and 10 years follow ups

Implant Diameter	No. of Implant	Failed Implant during the 5 years	Failed Implant during the 10 years	Survival rate during the 5 years	Survival rate during the 10 years
3.0 mm	17	5	8	70.6%	52.9%
3.8 mm	61	3	4	95.1%	93.4%
4.2 mm	92	2	3	97.8%	96.7%
4.6 mm	62	2	3	96.8%	95.2%
Total	232	12	18	94.8%	92.2%
Location					
Anterior	120	5	8	95.8%	93.3%
posterior	112	7	10	93.8%	91.1%

Table 2 shows the implants' survival rate after 5 years and 10 years of follow-up. The total survival rate of implants was 94.8% at the 5-year follow-up and 92.2% at the 10-year follow-up. In the 3.0 mm diameter implants, the lowest survival rate was 70.6% at the 5-year follow-up and 52.9% at the 10-year follow-up, whereas in the 3.8 mm diameter implants it was 95.1% and 93.4%, in the 4.2 mm diameter implants it was 97.8% and 96.7%, and in the 4.6 mm diameter implants it was 94.8% and 92.2%, respectively. The anterior overdenture survival rate was 95.8% at the 5-year follow-ups and 93.3% at the 10-year follow-ups, whereas the posterior overdenture survival rate was 93.8% and 91.1%, respectively.

Table 3: Prosthetic complication of maxillary overdenture during 5 years and 10 years follow ups

Prosthetic Complications	During the 5 years follow ups		During the 10 years follow ups		Total
	Anterior	Posterior	Anterior	Posterior	
Prosthetic teeth fractures	2	12	2	13	29
Premature wear of gaskets	5	3	3	7	18
Prosthesis loosening/shedding	1	6	1	7	15
Prosthesis flanges damages	2	2	2	3	9
Baskets damage	0	2	0	2	4
Prosthesis mobility	1	2	1	0	4
Screw loosening	0	1	0	2	3

In the prosthetic complications, most of the 29 implants had prosthetic tooth fractures, followed by 18 premature wear of gaskets, 15 prosthesis loosening/shedding, 9 damaged prosthesis flanges, 4 damaged baskets, and 3 implants with screw loosening.

DISCUSSION

Since the introduction of osteo-integrated implants, implant-supported overdentures have become a good treatment option for the completely edentulous patient. The present study examined the survival or failure rate of the implants and the prosthetic complications of the overdentures. The total survival rate of implants was 94.8% at the 5-year follow-up and 92.2% at the 10-year follow-up. This is similar to the study of Stefanie Kappel *et al*., [23], where the survival rate of implant-supported overdentures for the edentulous maxilla was 93.8% after a mean observation period of 3.1 years. According to the findings of Ma *et al*., [24] Raghoebar *et al*., [25], Watson *et al*., [26]; Zou *et al*., [27] in their studies, survival rates for implants that support overdentures in edentulous jaws range from 72.4% to 100%. In contrast to earlier findings in the literature, implant loss was more prevalent and severe in this study [28, 29]. Even lower survival rates are reported by Palmqvist *et al*., [30] and Widbom *et al*., [31] in their studies. According to Balaguer *et al*., [32], implants supporting overdentures in the maxilla are generally thought to have lower survival rates than those supporting mandibles. But according to Ma *et al*., [24], implant survival of maxillary overdentures appears unrelated to prosthetic design. Krennmair *et al.*, [33] demonstrated a cumulative 5-year survival rate higher than 98% with four implants put in the maxillary anterior region and anchored on a milled

bar in a trial on "planned" implant supported maxillary overdentures. In a different "planned" trial, Sanna *et al*., [34] demonstrated a successful outcome with four to six interconnected implants supporting an overdenture in the maxilla, with a cumulative survival rate.

According to this study, in the 3.0 mm diameter implants, the lowest survival rate was 70.6% at the 5-year follow-up and 52.9% at the 10-year follow-up, whereas in the 3.8 mm diameter implants it was 95.1% and 93.4%, and in the 4.2 mm diameter implants it was 97.8% and 96.7%, respectively. This result is similar to Rodolfo Reda *et al*.,'s [35] report, where the success rate of smaller-diameter implants is lower, especially if placed in posterior areas, compared to medium-diameter implants. In this study, there were prosthetic complications, most of the 29 implants had prosthetic tooth fractures, followed by 18 premature wear of gaskets, 15 crowns loosening/shedding, 9 damaged prosthesis flanges, 4 damaged baskets, and 3 implants with screw loosening.

In 1996, Jemt *et al*., [36] reported that 77.9% of overdentures experienced mechanical difficulties; this figure was confirmed in subsequent investigations by Visser and Slot [37, 38]. Retention loss in retention systems, wear and/or fracture of the teeth or the prosthesis, loss of adaption of the prosthesis's base, screw loosening or fracture, and abutment loss were the mechanical issues that occurred most frequently. However, some other authors listed resin fractures, dental problems, and the need for relining as often occurring mechanical issues. A recent systematic review [39] compared the differences between overdenture attachments, with and without splinting, comparing the mechanical complications suffered by bar-retained overdentures. It described the following: abutment or abutment screw loosening, relining, dental or resin fractures, and retention clip breakage, the same complications as observed in the present study. When Slot *et al*., [38] examined the prevalence of mechanical problems in the study, they discovered that the most frequent mechanical event with bar kinds of overdenture retention was the fracturing of prosthetic teeth or resin [40, 41].

CONCLUSION

Although some limitations have the current study, particularly the limited sample size, it is possible to conclude that the treatments outlined for the medium- to long-term rehabilitation of an edentulous maxilla are effective. Additionally, patients reported a high degree of satisfaction with the overdentures. The study's upper jaw overdenture implants had a survival rate of 92.9%. It is true that implant-supported maxillary overdentures have a high rate of survival and are safe and reliable treatment option. But it's obvious that biological and mechanical issues arise frequently and that they become more common over time. This study also suggests that dental professionals should put great effort into selecting dependable components and materials for implant-supported overdentures, and patients should be a part of well-structured maintenance programs after treatment with implant-supported overdentures to reduce the time needed to address complications.

REFERENCES

1. Hsu, Y. J., Lin, J. R., & Hsu, J. F. (2021). Patient satisfaction, clinical outcomes and oral health-related quality of life after treatment with traditional and modified protocols for complete dentures. *Journal of Dental Sciences*, *16*(1), 236-240. doi:10.1016/j.jds.2020.05.024. Epub 2020 Jun 8. PMID: 33384803; PMCID: PMC7770313.
2. Emami, E., de Souza, R. F., Kabawat, M., & Feine, J. S. (2013). The impact of edentulism on oral and general health. *International journal of dentistry*, *2013*, 498305. doi:10.1155/2013/498305. Epub 2013 May 8. PMID: 23737789; PMCID: PMC3664508.
3. Slot, W., Raghoebar, G. M., Cune, M. S., Vissink, A., & Meijer, H. J. (2016). Maxillary overdentures supported by four or six implants in the anterior region: 5-year results from a randomized controlled trial. *Journal of clinical periodontology*, *43*(12), 1180-1187. doi:10.1111/jcpe.12625.
4. Driscoll, C. F., Freilich, M. A., Guckes, A. D., Knoernschild, K. L., & Mcgarry, T. J. (2017). The Glossary of Prosthodontic Terms: Ninth Edition. *J Prosthet Dent*, 117, e1–e105.
5. Fernandez-Estevan, L., Selva-Otaolaurruchi, E. J., Montero, J., & Sola-Ruiz, F. (2015). Oral health-related quality of life of implant-supported overdentures versus conventional complete prostheses: retrospective study of a cohort of edentulous patients. *Medicina oral, patologia oral y cirugia bucal*, *20*(4), e450-458. doi:10.4317/medoral.20498. PMID: 26034930; PMCID: PMC4523258.
6. Boven, G. C., Raghoebar, G. M., Vissink, A., & Meijer, H. J. A. (2015). Improving masticatory performance, bite force, nutritional state and patient's satisfaction with implant overdentures: a systematic review of the literature. *Journal of oral rehabilitation*, *42*(3), 220-233. doi:10.1111/joor.12241. Epub 2014 Oct 13. PMID: 25307515.
7. von der Gracht, I., Derks, A., Haselhuhn, K., & Wolfart, S. (2017). EMG correlations of edentulous patients with implant overdentures

and fixed dental prostheses compared to conventional complete dentures and dentates: a systematic review and meta-analysis. *Clinical oral implants research*, *28*(7), 765-773.

8. Sivaramakrishnan, G., & Sridharan, K. (2016). Comparison of implant supported mandibular overdentures and conventional dentures on quality of life: a systematic review and meta-analysis of randomized controlled studies. *Australian dental journal*, *61*(4), 482-488.
9. El-Sheikh, A. M., Shihabuddin, O. F., & Ghoraba, S. M. (2012). Two versus three narrow-diameter implants with locator attachments supporting mandibular overdentures: a two-year prospective study. *International journal of dentistry*, *2012*, 285684. doi:10.1155/2012/285684. Epub 2012 Jun 18. PMID: 22754570; PMCID: PMC3382982.
10. Ueda, T., Kremer, U., Katsoulis, J., & Mericske-Stern, R. (2011). Long-term results of mandibular implants supporting an overdenture: implant survival, failures, and crestal bone level changes. *International journal of oral & maxillofacial implants*, *26*(2), 365-372. PMID: 21483890..
11. Roccuzzo, M., Bonino, F., Gaudioso, L., Zwahlen, M., & Meijer, H. J. (2012). What is the optimal number of implants for removable reconstructions? A systematic review on implant-supported overdentures. *Clinical oral implants research*, *23*, 229-237.
12. Mangano, C., Mangano, F., Shibli, J. A., Ricci, M., Sammons, R. L., & Figliuzzi, M. (2011). Morse taper connection implants supporting "planned" maxillary and mandibular bar-retained overdentures: a 5-year prospective multicenter study. *Clinical Oral Implants Research*, *22*(10), 1117-1124. doi: 10.1111/j.1600-0501.2010.02079.x
13. Frisch, E., Ziebolz, D., Ratka-Krüger, P., & Rinke, S. (2015). Double crown-retained maxillary overdentures: 5-year follow-up. *Clinical implant dentistry and related research*, *17*(1), 22-31. doi: 10.1111/cid.12087. Epub 2013 May 16. PMID: 23679159.
14. Slot, W., Raghoebar, G. M., Vissink, A., Huddleston Slater, J. J., & Meijer, H. J. (2010). A systematic review of implant-supported maxillary overdentures after a mean observation period of at least 1 year. *Journal of Clinical Periodontology*, *37*(1), 98-110. doi:10.1111/j.1600-051X.2009.01493.x. Epub 2009 Dec 7. PMID: 19995402.
15. Balaguer, J., Ata-Ali, J., Peñarrocha-Oltra, D., García, B., & Peñarrocha-Diago, M. (2015). Long-term survival rates of implants supporting overdentures. *Journal of Oral Implantology*, *41*(2), 173-177. doi: 10.1563/AAID-JOI-D-12-00178. Epub 2013 Jun 10. PMID: 23750606.
16. Schimmel, M., Srinivasan, M., Herrmann, F. R., & Mueller, F. (2014). Loading protocols for implant-supported overdentures in the edentulous jaw: a systematic review and meta-analysis. *International Journal of Oral & Maxillofacial Implants*, *29,* 271–286.
17. Di Francesco, F., De Marco, G., Carnevale, U. A. G., Lanza, M., & Lanza, A. (2019). The number of implants required to support a maxillary overdenture: a systematic review and meta-analysis. *Journal of prosthodontic research*, *63*(1), 15-24. doi:10.1016/j.jpor.2018.08.006. Epub 2018 Sep 28. PMID: 30269880.
18. Sadowsky, S. J. (2007). Treatment considerations for maxillary implant overdentures: A systematic review. *The Journal of Prosthetic Dentistry*, 97, 340–348. https://doi.org/10.1016/S0022-3913(07)60022-5
19. Gallucci, G. O., Benic, G. I., Eckert, S. E., Papaspyridakos, P., Schimmel, M., Schrott, A., & Weber, H. P. (2014). Consensus statements and clinical recommendations for implant loading protocols. *The International journal of oral & maxillofacial implants*, *29*, 287-290. doi:10.11607/jomi.2013.g4. PMID: 24660204.
20. Bergendal, T., & Engquist, B. (1998). Implant-supported overdentures: a longitudinal prospective study. *International Journal of Oral & Maxillofacial Implants*, *13*(2), 253-262. PMID: 9581412.
21. Klemetti, E. (2008). Is there a certain number of implants needed to retain an overdenture? *Journal of Oral Rehabilitation*, 35, 80–84. https:// doi.org/10.1111/j.1365-2842.2007.01825.x
22. Närhi, T. O., Hevinga, M., Voorsmit, R. A., & Kalk, W. (2001). Maxillary overdentures retained by splinted and unsplinted implants: a retrospective study. *International Journal of Oral & Maxillofacial Implants*, *16*(2), 259-266. PMID: 11324214.
23. Kappel, S., Klotz, A. L., Eberhard, L., Lorenzo Bermejo, J., Rammelsberg, P., & Giannakopoulos, N. N. (2021). Maxillary implant overdentures on two or four implants. A prospective randomized cross-over clinical trial of implant and denture success and survival. *Clinical Oral Implants Research*, *32*(9), 1061-1071. DOI: 10.1111/clr.13800
24. Ma, S., Tawse-Smith, A., De Silva, R. K., Atieh, M. A., Alsabeeha, N. H., & Payne, A. G. (2016). Maxillary three-implant overdentures opposing mandibular two-implant overdentures: 10-year

surgical outcomes of a randomized controlled trial. *Clinical Implant Dentistry and Related Research*, *18*(3), 527-544. https://doi.org/10.1111/cid.12325

25. Raghoebar, G. M., Meijer, H. J., Slot, W., Slater, J. J., & Vissink, A. (2014). A systematic review of implant-supported overdentures in the edentulous maxilla, compared to the mandible: how many implants. *Eur J Oral Implantol*, *7*(Suppl 2), S191-S201. PMID: 24977255.
26. Watson, R. M., Jemt, T., Chai, J., Harnett, J., Heath, M. R., Hutton, J. E., ... & Taylor, R. (1997). Prosthodontic treatment, patient response, and the need for maintenance of complete implant-supported overdentures: an appraisal of 5 years of prospective study. *International Journal of Prosthodontics*, *10*(4), 345-354. PMID: 9484045.
27. Zou, D., Wu, Y., Huang, W., Wang, F., Wang, S., Zhang, Z., & Zhang, Z. (2013). A 3-year prospective clinical study of telescopic crown, bar, and locator attachments for removable four implant-supported maxillary overdentures. *International Journal of Prosthodontics*, *26*(6), 566-5573. doi:10.11607/ijp.3485. PMID: 24179972.
28. Kern, J. S., Kern, T., Wolfart, S., & Heussen, N. (2016). A systematic review and meta-analysis of removable and fixed implant-supported prostheses in edentulous jaws: Post-loading implant loss. *Clinical Oral Implants Research*, 27, 174–195. https://doi.org/10.1111/clr.12531
29. Rammelsberg, P., Lorenzo-Bermejo, J., & Kappel, S. (2017). Effect of prosthetic restoration on implant survival and success. *Clinical Oral Implants Research*, 28, 1296–1302. https://doi.org/10.1111/clr.12974
30. Palmqvist, S., Sondell, K., & Swartz, B. (1994). Implant-supported maxillary overdentures: outcome in planned and emergency cases. *International Journal of Oral & Maxillofacial Implants*, *9*(2), 184-190. PMID: 8206554.
31. Widbom, C., Soderfeldt, B., & Kronstrom, M. (2005). A retrospective evaluation of treatments with implant-supported maxillary overdentures. *Clinical Implant Dentistry and Related Research*, 7, 166–172.
32. Balaguer, J., Ata-Ali, J., Peñarrocha-Oltra, D., García, B., & Peñarrocha-Diago, M. (2015). Long-term survival rates of implants supporting overdentures. *Journal of Oral Implantology*, *41*(2), 173-177. https://doi.org/10.1563/AAID-JOI-D-12-00178
33. Krennmair, G., Krainhöfner, M., & Piehslinger, E. (2008). Implant-supported maxillary overdentures retained with milled bars: maxillary anterior versus maxillary posterior concept--a retrospective study. *International Journal of Oral & Maxillofacial Implants*, *23*(2), 343–352.
34. Sanna, A., Nuytens, P., Naert, I., & Quirynen, M. (2009). Successful outcome of splinted implants supporting a 'planned'maxillary overdenture: a retrospective evaluation and comparison with fixed full dental prostheses. *Clinical Oral Implants Research*, *20*(4), 406-413.
35. Reda, R., Zanza, A., Di Nardo, D., Bellanova, V., Xhajanka, E., & Testarelli, L. (2022). Implant Survival Rate and Prosthetic Complications of OT Equator Retained Maxillary Overdenture: A Cohort Study. *Prosthesis*, *4*(4), 730-738. https://doi.org/10.3390/prosthesis4040057
36. Jemt, T., Chai, J., Harnett, J., Heath, M. R., Hutton, J. E., Johns, R. B., ... & Herrmann, I. (1996). A 5-year prospective multicenter follow-up report on overdentures supported by osseointegrated implants. *International Journal of Oral & Maxillofacial Implants*, *11*(3), 291-298. PMID: 8752550.
37. Visser, A., Raghoebar, G. M., Meijer, H. J., & Vissink, A. (2009). Implant-retained maxillary overdentures on milled bar suprastructures: a 10-year follow-up of surgical and prosthetic care and aftercare. *International Journal of Prosthodontics*, *22*(2), 181-192. PMID: 19418867.
38. Slot, W., Raghoebar, G. M., Cune, M. S., Vissink, A., & Meijer, H. J. (2019). Four or six implants in the maxillary posterior region to support an overdenture: 5-year results from a randomized controlled trial. *Clinical oral implants research*, *30*(2), 169-177. doi:10.1111/clr.13403. Epub 2019 Feb 3. PMID: 30636064.
39. Leão, R. S., Moraes, S. L. D., Vasconcelos, B. C. E., Lemos, C. A. A., & Pellizzer, E. P. (2018). Splinted and unsplinted overdenture attachment systems: a systematic review and meta-analysis. *Journal of oral rehabilitation*, *45*(8), 647-656. doi:10.1111/joor.12651. Epub 2018 Jun 7. PMID: 29761853.
40. Ekfeldt, A., Johansson, L. Å., & Isaksson, S. (1997). Implant-supported overdenture therapy: a retrospective study. *International Journal of Prosthodontics*, *10*(4), 366-374. PMID: 9484047.
41. Cakarer, S., Can, T., Yaltirik, M., & Keskin, C. (2011). Complications associated with the ball, bar and Locator attachments for implant-supported overdentures. *Med Oral Patol Oral Cir Bucal*, 16(7), 953-959. doi:10.4317/medoral.17312. PMID: 21743398.