

Volume 10, Issue 07, July 2024,
Publish Date: 20-07-2024
Doi <https://doi.org/10.55640/ijmsdh-10-07-04>

International Journal of Medical Science and Dental Health

(Open Access)

EVALUATION OF OSSEOINTEGRATION AND FUNCTIONALITY IN IMMEDIATE IMPLANT-SUPPORTED PROSTHESES FOLLOWING SINUS LIFT SURGERIES: A SYSTEMATIC NARRATIVE REVIEW.

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ABSTRACT

The evidence-based evolution of dental implantology has made immediate implant-supported prostheses following sinus lift surgeries a straightforward means for the replacement of missing teeth. Achieving primary stability is a key element to the success of osseointegration, especially in cases with limited bone quantity such as the posterior maxilla. A systematic narrative review on the osseointegration and function of immediate implant-supported prostheses in sinus lift surgeries was conducted. To find the articles, we searched databases including SCOPUS, Google Scholar, and PUBMED from 2019 to 2024 using keywords such as immediate implant placement, sinus lift surgery, osseointegration. Studies published only in English which primarily included human subjects and investigated the cause of immediate implant placement surgeries combined with alveolar bone grafting were also selected as inclusion criteria. You can find the thematic structure on this study to classify and analyze. Autogenous grafts, allografts and xenografts performed very well with high successful rates reported by various studies for all types of bone substitutes ranging from 73% to almost perfect conditions (98.3%-grafts; 97.2%-implants). Surface modification of implant like sand/salt blasting and acid etching improves osseointegration with decreased bacterial adherence. Precise surgical techniques were essential to prevent complications such as sinus membrane perforation. Surprisingly,

the survival rate of immediate implant placement was high or sometimes equivalent to that for delayed. Improvement in patient satisfaction was achieved by reducing the treatment time and emerging with better functional & aesthetic outcomes straightaway. An immediate implant-supported prosthesis in sinus lift surgery provides advantages of high success rates, less treatment time and more patient satisfaction. Nevertheless, the same meticulous surgical technique and an appropriate choice for graft material and implant surface are mandatory to get a predictable result.

INTRODUCTION

Dental implantology is an evolving field and over the past decades, dental implants have become one of the most desired methods for replacing a missing tooth ⁽¹⁾. Primary stability, essential for osseointegration following dental implant placement requires adequate bone volume. On the other hand, obtaining sufficient bone height and density can become more of a challenge in cases such as posterior maxilla, where factors ranging from bone resorption following tooth loss to pneumatization of the sinus are at play.

The maxillary sinus is an air-filled cavity in the body of the maxilla and causes lateral growth along with pneumatization into the alveolar ridge following tooth extraction leading to decreased bone height available for dental implants ⁽²⁾. This anatomic obstacle makes it imperative to perform a procedure called the sinus lift surgery in order to augment bone volume at the site of the sinus and create space for implant placement ⁽³⁾. The method entails lifting the Schneiderian membrane (lining of the sinus cavity) and placing bone graft substance into the floor of Extensive experience has demonstrated that this material is ultimately replaced by new mature lamellar bone.

There are two primary types of sinus lift surgeries including lateral window technique and the transalveolar (or osteotome) techniques. The lateral window technique consists of opening a window in the buccal wall to access the sinus membrane and, with time, the transalveolar approach has been developed as a less invasive procedure that is conducted either through an existing tooth socket or over residual alveolar ridge ⁽⁴⁾. The objective with both methods is to obtain adequate bone augmentation for the successful osseointegration of dental implants.

The typical implant procedure involves using the inadequate residual alveolar bone of a nongrafted maxilla, making it only appropriate for lower seated implants ⁽⁵⁾. Traditional two-stage protocols place an emphasis on allowing adequate healing time period following sinus augmentation and before implant placement (9-12 months) to permit graft maturation & osseointegration. The unearthing of the implants is done only after this phase that has its healing period and then we wait for yet another healing period before loading with a prosthetic restoration. Although this staged approach can be effective, it typically prolongs the duration of treatment and requires multiple surgical interventions (something that is not always feasible for patients).

Concurrent placement of implants with sinus augmentation, known as immediate implant placement is another option that can potentially accelerate the overall treatment time ⁽⁶⁾. Used in conjunction with Expedited Loading protocols where the use of a prosthetic restoration is added soon after implant placement, this approach has the ability to offer immediate advantages over both health and beauty. Immediate implant-supported prosthesis can meet patient expectations by reducing the waiting time for replacement of teeth and providing a fewer number of surgeries.

Sinus lift surgeries together with immediate implant placement and loading, however require a few success factors to be fulfilled. The most important of these is to achieve the primary stability and it is very essential for osseointegration (bone growth around an implant) ⁽⁷⁾. The selection of bone graft material, implant surface topography and the surgical procedure performed as well as loading regimes have all been implicated in influencing osseointegration ⁽⁸⁾. In addition, the functional results with variables such as survival rates of implants and prosthetic success merely highlighting patient satisfaction would be inadequate for evaluating this integrated approach.

The purpose of this narrative review is to systematically evaluate the existing literature on immediate implant-supported prostheses in sinus lift surgeries regarding osseointegration and functionality. In this review, we aimed to provide a comprehensive overview of the clinical benefits and challenges associated with immediate implant placement into sinuses augmented simultaneously wearing regard of implants outcomes (clinical/ survival rate), complications rates, patient quality-of-life. By critically appraising the available literature, this review will inform on how to standardize therapeutic protocols that hopefully lead and guide towards more predictable outcomes for patients seeking treatment via immediate loading of dental implants.

METHODOLOGY

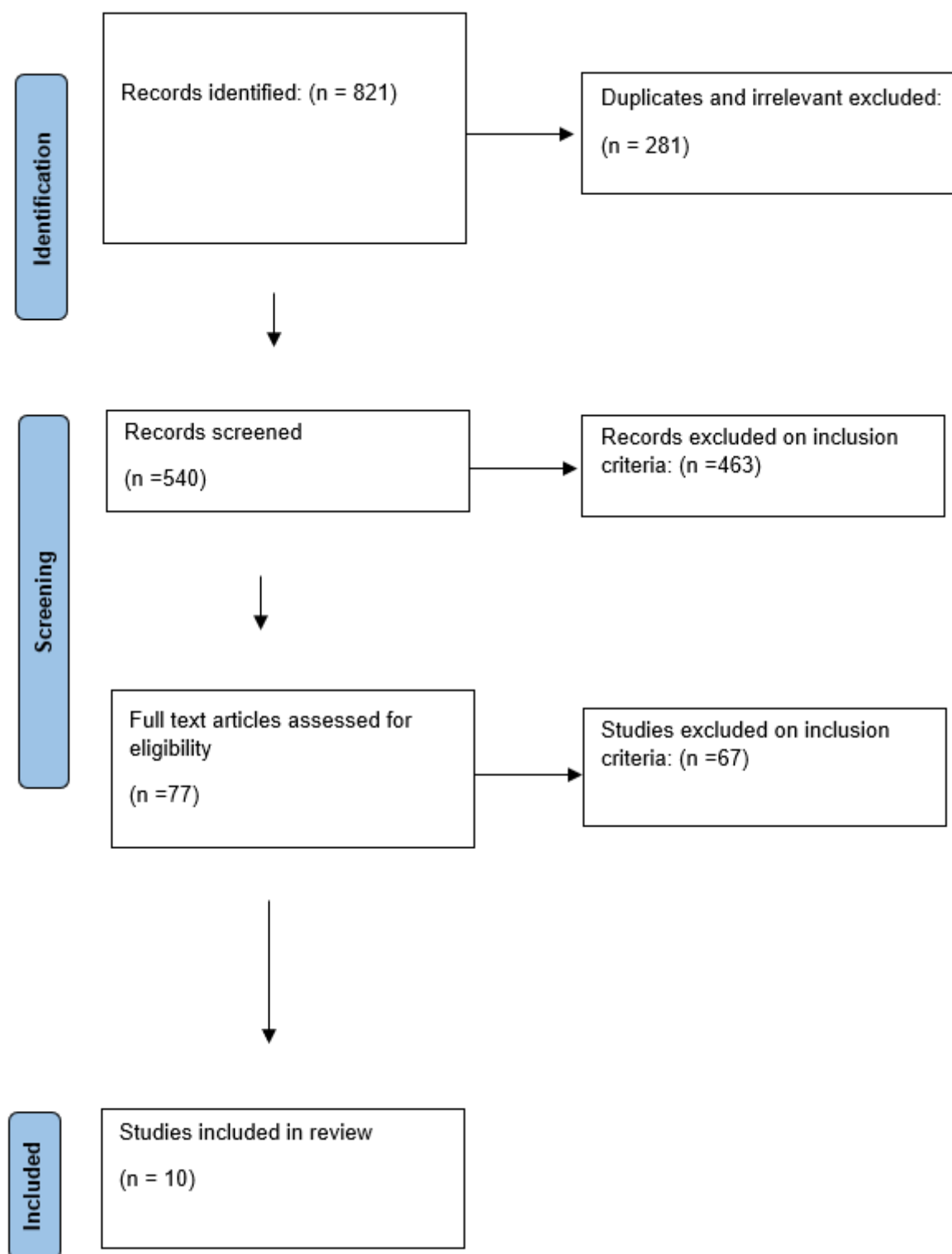
To evaluate the osseointegration and related outcomes of immediate implant-supported prostheses following sinus lift surgeries, a systematic narrative review was conducted. A comprehensive search of reliable databases such as Scopus, Google Scholar and PubMed was carried out between 2019 through to 2024 in order to accomplish this. Key search terms used were "immediate implant placement," "sinus lift surgery," "osseointegration," "implant-supported prostheses," "bone graft materials," "implant surface characteristics," and "clinical outcomes."

Inclusion and Exclusion Criteria

Articles were included into the review if they reported on any number of immediate implant placement procedures in combination with a sinus lift, human studies carried out within the specified time window and published in English language that gave valuable information about osseointegration and clinical outcomes. Studies that did not met these criteria, broke methodological rigor, or do not significantly contribute to the knowledge of immediate implant-supported prostheses in sinus lift surgeries have been excluded. Every study included was critically appraised to verify relevance and applicability to the review aims.

Categorization and Analysis

These studies were then classified based on the thematic areas that addressed osseointegration and the functionality of immediate implant-supported prostheses. Such categories involved bone replacement materials, implant surface, types of operations, treatment results, percentiles of prosthodontic outcomes and patient satisfaction and complications. The information derived from the themes were thematically analyzed for a comprehensive review of the success determinants of immediate implant-supported prostheses as part of a sinus graft process. The study rigor fostered an analytical insight in the pathways of those outcome affecting variables.



RESULTS

Osseointegration in Immediate Implant Placement

Osseointegration is the prerequisite of long-term survival of dental implants which refers to a direct structural and functional connection between living bone resulting in load-bearing implant surface ⁽⁹⁾. Immediate implant placement particularly after sinus lift surgeries is challenging and unique with

successful osseointegration. Several parameters could influence the outcome, such as the selection of bone graft materials. In this section, these factors will be illustrated by the literature evidence.

Bone Grafting Materials

The bone graft material influences the degree of osseointegration in sinus lift surgery ⁽¹⁰⁾. These types of grafts are preferred by surgeons due to their osteogenic, osteoinductive, and osteoconductive properties making the autogenous bone graft from the patient body referred as gold standard. Nevertheless, use of these is constrained by donor site morbidity and availability. Allografts, xenografts and alloplasts are often used as alternatives.

In their 15-year retrospective study, Vanessa Helena Jamcoski et al examined the success rates of maxillary sinus augmentation and implants, considering bone substitute types, presurgical bone height, and membrane perforation ⁽¹¹⁾. The results revealed a high success rate for both grafts (98.3%) and implants (97.2%), with no significant difference in success rates among the different bone substitutes. Failures were minimal, with only 8 grafts (1.7%) and 21 implants (2.8%) failing. A higher success rate was observed for grafts (96.5%) and implants (97.4%) when the presurgical bone height was ≥ 4 mm. Additionally, the presence of membrane perforation did not significantly impact the success rates, with grafts and implants in cases with perforations achieving success rates of 97.96% and 96.2%, respectively. The follow-up periods for rehabilitation ranged from 3 months to 13 years. The authors concluded that maxillary sinus lift is a viable surgical technique for enabling implant placement with predictable long-term success, regardless of the bone substitute material used, and that membrane perforation does not significantly compromise the success rates of grafts and implants.

Tartaglia et al. conducted a retrospective study to evaluate and compare the clinical outcomes of two sinus augmentation grafting protocols—using either a xenograft or a blood clot alone—over a 72-month follow-up period ⁽⁵⁾. Patients who had concurrent lateral sinus floor augmentation and implant placement were included in the study. These patients were grouped according to the grafting material used and the residual alveolar bone height (RABH) (4 to 6 mm or >6 mm) beneath the maxillary sinus. For every material group, Kaplan–Meier survival estimates were computed at one, three, and six years. 35 implant failures out of 289 that were implanted in 136 patients were documented. After one year, the overall survival rates were 91.1% and 81.6% for the xenograft and 85.9% for the blood clot alone, and 91.1% and 78.7% for the six-year period. The study found that xenograft-based interventions were more successful than blood clot-only ones in patients with 4-6 mm RABH. In order to increase implant success rates, sinus floor augmentation using grafting materials should be used for instances with low RABH.

Implant Surface Characteristics

A lot of research has focused on the modification of implant surfaces for superior osseointegration qualities. By increasing the surface area for bone contact and modulating cellular responses that facilitate osseointegration, implant surfaces rendered to create micro (sandblasted/acid-etched) or nano roughness show enhanced biological properties such as only osteoinductive diversity ⁽¹²⁾.

The challenges of oral rehabilitation in both healthy and damaged bone have led to an evolution in implant surface design. In order to address the prevalent issue of peri-implantitis and consequent implant loss, implant surfaces have been altered to include desirable characteristics, hence improving implant success rates and broadening their range of applications. To accomplish these objectives, a

variety of implant surface modifications, including various physical, chemical, and biological methods, have been implemented on a wide array of materials, including polyether ketone, titanium, and zirconia. The best adjustments maximise the surface's interface with the surrounding bone of the implant, promoting osseointegration and reducing bacterial colonisation, which lowers the danger of biofilm development ⁽¹³⁾.

Surgical Technique

In order to obtain primary stability and optimal osseointegration in immediate implant placement at sinus lift surgery, the surgical technique is essential. A meticulous technique for lifting the sinus membrane is needed to prevent its perforation and compaction of bone graft in a method that can functionally support dental implant.

In order to assess the survival rate of implants inserted into the posterior maxilla utilising an osteotome and sinus lift augmentation method without the use of biomaterials, Andrés-García et al. (Year) carried out research. Tatum's suggestion of elevating the sinus maxillary floor via the side window is the method that is most often used and well-documented. Summers (1994) presented a method that permitted the implant to be placed in the same surgical act as the elevation of the sinus floor from a crestal approach using an osteotome. The study's objective was to assess the survival of thirty-two implants positioned in the posterior maxilla using an osteotome-only sinus lift augmentation procedure with fewer than five millimetres of available bone. The study's findings demonstrate a 100% survival rate for 32 implants inserted without the use of graft material in scenarios where there was initially 2 to 5 mm of available bone. The method of infra-drilling provides an enhancement in the main stability of implants, enabling sufficient osteointegration. Twelve weeks after placement, implants were charged. Even in the instances when a positive Valsalva manoeuvre was seen, spontaneous bone growth was seen in every single case. By using this suggested method, less time is spent on therapy and more invasive maxillary sinus augmentation procedures are not required ⁽¹⁴⁾.

Clinical Outcomes and Success Rates

Furthermore, the clinical success of this technique has shown high survival rates and successful integration of the implants. These have high comparable survival rates or even sometimes higher than the delayed implant placement. For example, Khan et al. 2020 conducted a study to diagnose the reliability of sinus lift procedures, evaluate the success between dental implants placed after closed vs. open sinus lift procedures, and placed immediately vs. delayed ⁽¹⁵⁾. This research was a retrospective study at Islamic International dental college and hospital and park road practice, Islamabad, Pakistan. A total sample size was 58 implants in 35 consecutive patients. Sinus lift procedures, whether bilateral or unilateral, using open or closed, and delayed or immediate dental implantation. At the end, osseointegration was evaluated in all cases as a success or failure. 93 % of Sinus lift procedures were successfully done in 95.2 % integrated with dental Implants which is very presentable result without discrepancies in all 93 sinuses lift procedures. In some patients, there was accidental perforation of the membrane which was sutured and, in some, capped with a barrier membrane, which depended on the measure of an unfavourable defect in patients. The results complement the previously published data confirming that the surgical procedure of sinus lifting is a reliable surgical procedure, which ensures a high survival rate of dental implants, either delayed or immediate implantation.

Functionality of Immediate Implant-Supported Prostheses

The performance of immediate implant-supported prostheses (IISPs) in sinus lift procedures is an important clinical parameter, which effectively affects the survival rate and long-term esthetics as well as quality of life for patients. In this section, based on the literature describing clinical evidence in operation of these aspects we come to a more holistic picture as regards to advantages and obstacles associated with such strategies.

Implant Survival Rates

An implant survival rate is an important index for the function and success rate of immediate functional loading prostheses supported by implants. Interestingly, there are a great number of studies pointing to the later tensile force, even comparable with those papers about survival rate on implants inserted just after scaffold installation.

Bortoluzzi et al, conducted a comparative study to assess the success rate and reliability of immediately inserted dental implants in sinus lift procedures, particularly focusing on cases with very low residual bone heights (<4 mm) in the posterior maxilla (16). The study divided patients into two groups based on maxillary alveolar height: Group 1 with bone height ≥ 4 mm and Group 2 with bone height <4 mm. Over a 24-month follow-up period, 13 implants were installed in Group 1 and 8 in Group 2. The overall success rate for the implants was 95.2%, with Group 1 achieving a 100% success rate and Group 2 achieving an 87.5% success rate. Despite the apparent differences, statistical significance was not reached between the groups (Fisher's exact test, $P = 0.38$). The findings suggest that while simultaneous surgery for sinus lifting, grafting, and implant placement in patients with very low bone heights can be performed safely, the success rates are lower compared to those with higher residual bone heights (Bortoluzzi et al., Year).

Kim et al. 2020 evaluated radiologic and clinical results of immediate implant placement following tooth extraction with simultaneous lateral sinus augmentation (17). The 1-year survival rate was 97.06%, showing that immediate implant placement with lateral sinus augmentation is a reliable procedure.

Prosthetic Success

Prosthetic success was related to the stability, functionality, and aesthetic of implant-supported restoration. Patients attach much value to the functionality and aesthetic of the implant-supported restoration, thus immediate loading can provide immediate attaining of this goal.

The effect of a sinus lift on face structure is usually mild. To provide the best possible result, your operation will be carefully planned by an oral surgeon. A sinus lift helps to provide a fuller and healthier look by increasing the volume and density of bone in the upper jaw, especially in the mid- and lower face (18).

Patient Satisfaction and Quality of Life

Patient satisfaction and quality of life are vital outcomes used to establish the efficacy of immediate implant-supported prostheses. All these outcomes of immediate implant placement and loading can significantly improve patient satisfaction by reducing the overall treatment time and offering immediate functional and aesthetic benefits. Dong et al. conducted a study to evaluate patient satisfaction with single implant treatments and identify influencing factors, aiming to improve the quality of oral implantology (19). The results showed an overall satisfaction score of 69.05 ± 7.10 . Lower satisfaction scores were significantly associated with patients who underwent bone augmentation and

those with a longer period of teeth loss. Key factors contributing to reduced satisfaction included pain, complications, duration of operative time, and healing response. Additionally, aesthetics, psychological impact, and chewing function satisfaction decreased with extended tooth loss periods. Over half of the respondents prioritized the survival time and success rate of implants. The study concludes that bone augmentation and the duration of teeth loss negatively impact patient satisfaction, emphasizing the need for improved awareness of oral hygiene and optimization of the dental implant process.

Complications and Risk Management

Despite high functionality of immediate implant-supported prostheses, possible complications should be taken into the account. Stacchi et al. conducted a retrospective multicentre study to assess the incidence of intraoperative complications and early implant failure after transcrestal sinus floor elevation in sites with minimal residual bone height (RBH ≤ 5 mm) (20). With an early implant failure rate of 2.8%, the research examined the clinical and radiological records of 430 patients treated across seven clinical centres and found that 418 of the 430 implants were operating adequately one year after loading. Large sinus cavities and membrane perforation were strongly linked to early implant failures. Adverse effects that were noted included oro-antral fistula (0.2%), acute sinusitis (0.9%), membrane perforation (7.2%), and benign paroxysmal positional vertigo (0.5% of osteotome patients). Wider sinuses were shown to have a greater rate of perforations due to a significant direct link between bucco-palatal sinus width and sinus membrane perforation. According to the study's findings, membrane perforation and bucco-palatal maxillary sinus width are strongly associated with early implant failure. This highlights the need of carefully taking sinus architecture into account while performing transrectal sinus elevation treatments.

DISCUSSION

After sinus lift procedures, the assessment of immediate implant-supported prostheses demonstrates a complex interaction of variables impacting osseointegration and functioning. For osseointegration to be effective, primary stability is still essential, particularly in the posterior maxilla where bone resorption and sinus pneumatization pose difficulties. In this case, choosing the right bone transplant materials is essential. Because of their osteogenic qualities, autogenous bone transplants are the gold standard; nonetheless, they have drawbacks, including morbidity and availability at the donor location. As a result, substitutes such as alloplasts, xenografts, and allografts have been investigated. Research shows that these materials are effective in sinus lift treatments, as shown by high success rates ⁽¹¹⁾ ⁽⁵⁾.

Features of the implant surface have a big impact on osseointegration. Improvements in implant surface design, such as acid etching and sandblasting, have enhanced the biological characteristics of implants, improving osseointegration and enabling better bone-implant contact ⁽¹²⁾. Additionally, by reducing bacterial colonization, these surface alterations lessen the risk of peri-implantitis and increase the success rates of implants overall ⁽¹³⁾. Therefore, improving the osseointegration results requires modifying the implant surfaces.

Another crucial element is the surgical method used for sinus lift and prompt implant implantation. According to studies, maintaining primary stability and optimum osseointegration requires careful procedures to avoid sinus membrane perforation and guarantee correct compaction of bone graft material ⁽¹⁴⁾. The success of the implants is directly impacted by the surgical accuracy, underscoring the significance of technique in immediate implant-supported prostheses.

Promising results have been seen in the clinical outcomes and success rates of immediate implant-supported prostheses in sinus lift surgeries. Research has shown that implants inserted right after sinus lift procedures have excellent survival rates; some studies even suggest that these implants perform as well or better than those inserted later ⁽¹⁵⁾. Because it may shorten the duration of therapy overall and minimise the need for surgical procedures, quick loading is a desirable choice. According to Dong et al. (2019), patients' quality of life is enhanced by shorter treatment durations since they provide faster functional and cosmetic results ⁽¹⁹⁾.

Even though immediate implant-supported prostheses have a high success rate and good functioning, possible problems need to be closely monitored. Although they are relatively uncommon, complications include acute sinusitis, implant displacement into the sinus canal, and perforation of the sinus membrane highlight the need of careful surgical technique and planning ⁽²⁰⁾. Wider sinuses are associated with greater rates of membrane perforation, indicating that anatomical factors play a critical role in reducing risks.

When assessing the efficacy of immediate implant-supported prostheses, patient happiness and quality of life are critical performance indicators. Research indicates that patient satisfaction is greatly increased when treatment duration is shortened and rapid functional and cosmetic advantages are provided ⁽¹⁹⁾. Immediate loading techniques efficiently match patient expectations by reducing the waiting time for prosthesis restoration, which raises satisfaction and enhances quality of life.

CONCLUSION

Following sinus lift surgery, the concomitant use of immediate implant-supported prostheses presents a promising option for improving patient outcomes and high success rates have been reported regarding osseointegration and survival. This is largely because of the incorporation of cutting-edge bone graft materials, microsurgical protocols and implant surface enhancements. In addition of decreasing treatment period, immediate implant placement and loading offer additional therapeutically advantages for patients which result in enhanced patient satisfaction due to immediate functionally and aesthetically restoration. The fulfilment of these procedures is determined not only by the materials selected but also the successful organization, planning and execution of them.

However, the results of this review are promising in nature yet there exist certain limitations that need to be acknowledged. The sample sizes, time of supplementation and methodological differences have differed among studies, so that it is harder to standardize these findings across other contexts. There could also be an impact of patient population and bone health heterogeneity on how generalizable the results are. Compounding this problem is the use of retrospective datasets and publication bias, both of which may make it difficult to interpret outcomes. Ideally, future research should focus on ameliorating these limitations through larger and randomized controlled trials with standardized protocols.

The future for dental implantology will greater based on innovation and research with targeting to make immediate implants effort more predictable to them. New biomaterials, such son as growth factor enriched graft materials and bioactive surfaces provide potential for implant osseointegration acceleration with the subsequent shortening of healing times. In addition, the use of digital technologies that combine 3D imaging with computer-aided design could assist in maximizing surgical accuracy and results. Thus, long-term studies are warranted on such interventions to assess their durability and

therapeutic effectiveness for the continued advancement in this field towards processed strategy development helping us refine therapeutics doses over prolonged patient care.

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