

Indirect Sinus Lift: An Overview of Different Techniques

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Abbreviations: HySiLift: Hydraulic Sinus Lift Technique; β -TCP: Tricalcium phosphate; PRP: Platelet Rich Plasma

ABSTRACT

The common physiological changes in edentulous posterior maxilla are the pneumatization of the maxillary sinus and related vertical bone loss. The close proximation of sinus to the crestal bone is a limiting factor for the dental implant placement in the posterior maxilla. Therefore, numerous techniques were implemented to elevate the sinus floor to increase the vertical bone height. The indirect sinus lift is one of the safest and easiest ways of technique that has been introduced in clinical implant dentistry. In this article is expressed an overview of different techniques of indirect sinus lifts.

Clinical Relevance: The general knowledge of different types of indirect sinus lifts will help to utilize them according to the case and the available resources.

Background: To provide an overall summary of different types of indirect sinus lift techniques in one article. The indirect sinus lifts are case sensitive therefore this manuscript will emphasis the indications and limitations of each method when they are applying on patients.

Introduction

The maxillary sinus (or antrum of Highmore) is a pyramid-shaped air-filled space lying within the bilateral maxillae, lateral to the nasal cavity, superior to the maxillary teeth, inferior to the orbital floors, and anterior to the infratemporal fossa. It is present at birth and develops until around the age of 14 years. Maxillary sinuses are the largest among paranasal sinuses [1], with an average of 12.5 mL in volume [2]. They are lined by a thin bilaminar mucoperiosteal membrane known as the Schneiderian membrane. It comprises with a single-cell osteogenic periosteal layer (cambium layer) on the bone side and ciliated pseudostratified columnar epithelium (respiratory epithelium) on the lumen side. Even though the pneumatization is a poorly understood physiological process, itself causes the expansion of maxillary sinus into the adjacent anatomical structures [3]. In addition, there are some factors such as heredity, craniofacial configuration, nasal mucous membrane pneumatization, sinus surgeries, bone density, air pressure within the sinus and growth hormones may influence the maxillary sinuses pneumatization [4,5]. With the advancement of implant dentistry, the most popular and predictable modality of replacement of missing teeth is dental implants. But, to achieve better osseointegration after placement of an implant there

should be good quality and quantity of live bone right around the osteotomy, at least 2mm or more [6].

That fundamental requirement may be compromised in edentulous posterior maxilla in the vertical direction due to pneumatization of the maxillary sinus or close proximation of sinus floor to the crestal bone. To overcome that limitation, the sinus lift procedure has been invented in the mid-1970s. There onwards, several techniques and procedures were introduced into the implant dentistry. The rationale behind that all the techniques was an elevation of the sinus membrane to create a sub-antral space for increasing the vertical bone height. Currently, in order to reconstruct the atrophic maxillae, different bone grafting methods are used as autogenous, homogenous and heterogenous grafts, as well as synthetic biomaterials [7]. The accurate diagnosis and a better understanding of bone remodeling at posterior maxilla may be highly valuable for precise dental implant therapy. Therefore, proper patient selection can lead to long the success of the sinus lifting treatments for the deficient posterior maxilla. There are many techniques that are available for sinus lifting. Basically, they can be divided into two broad categories as

- 1) The direct method: with lateral antrotomy as a one or two-step procedure and
- 2) The indirect method: with the osteotome technique with a crestal approach. The indirect sinus lift is also called as subantral sinus augmentation, subcrestal augmentation, sinus floor elevation or transcrestal approach.

Here onwards described the evidence available in literature on different techniques in indirect sinus lift that are used for implant placement in the pneumatized posterior maxilla.

Inflatable Catheter Technique

The first maxillary sinus lift procedure was performed by Oscar Hilt Tatum Jr, in 1974 [8]. This was followed by placement of two endosteal implants and their restorations. During the year 1975–1979, much of the sinus floor elevation was performed using inflatable catheters. Tatum first presented this novel concept at The Alabama Implant Congress in Birmingham in 1976 and published an article describing the procedure in 1986. Dr Philip Boyne was introduced to the procedure by Tatum in 1977 or 1978. The first publication on the technique was authored by Boyne and James in 1980 when they published case reports of autogenous grafts placed into the sinus and allowed to heal for 6 months, which was followed by the placement of blade implants. Trans crestal sinus lift using the sinus balloon is a minimally invasive procedure involving few intraoperative complications. Peñarrocha Diago M, et al. [9] revealed that they were able to perform trans crestal sinus lift from 3 mm of residual bone, gaining a mean height of up to 8.7 mm, and with a 100% implant success rate one year after prosthetic loading.

Summers Osteotome Technique

In 1994 Summers introduced the sinus lift technique with the use of osteotomes to elevate the membrane. It was eliminated hammering and making the technique more comfortable for the patient combined with graft material around the implant [10]. This was also known as bone-added osteotome sinus floor elevation technique [11]. This is conceded as a less traumatic and minimally invasive method. The main limiting factors of this technique are the availability of >5mm residual bone height to prevent the membrane perforation and low primary stability of the implant [11]. On the other hand, this technique was a well-validated surgical option when the residual bone height was \geq to 5-6 mm [10,12]. The survival rate of implants placed simultaneously with indirect sinus lift with bone graft material ranges between 93.5% and 100% [13]. Further, the survival rate of the osteotome-installed implants after a mean follow-up time of 3.2- years was 97.4% in Pjetursson study. There were 3 implants lost before loading and another three were lost in the first and second year. According to the residual bone height, the survival rate was 91.3% for implant sites with 4 mm residual bone height, and 90% for the sites with 4-5 mm bone height, when compared with that of 100% in sites with the bone height of above 5 mm. According to implant length, the survival rates were 100%

for 12 mm, 98.7% for 10 mm, 98.7% for 8 mm and only 47.6% for 6 mm implants. This outcome has evidently shown bone height gain ($7.8 \text{ mm} \pm 0.86 \text{ mm}$) which is greater than the average of the osteotome technique [14,15].

Intralift Technique

Piezoelectric technology is proposed by Torrella et al for the lateral osteotomy surgeries [16]. Based on the use of piezoelectric surgery, sinus lift technique becomes simplified and less intervention as atraumatic as possible. Troedhan and colleagues have developed the Intralift technique to elevate the sinus floor by using piezoelectric surgery based on a specific set of tips for the application of ultrasound. The high-power ultrasonic instruments allow the osteotomies to be made even, in thicker compact cortical bone. The advantage of this system is that it does not cut the soft tissues. Therefore, this surgical instrument can be used to elevate the sinus membrane without perforating it. The piezoelectric surgical sets consist of many different inserts from osteotomies, to diamond-cutting inserts. Immediately after the window is made the sinus membrane is separated from the bone, and a hydropneumatics pressure of the physiologic saline solution is subjected to the piezoelectric cavitation [17]. Vercellotti and colleagues [18] in Italy performed 21 bony window osteotomies by using Piezo surgery System on 15 patients. The inserts were used with a vibration 60-210 mm with power exceeding 5W. Autogenous bone grafts and platelet-rich plasma were used for all the sinus augmentations in this study. Of the 21 osteotomies, only one resulted in membrane perforation and there was a 95% success rate.

Hydraulic Sinus Lift Technique

In this method, the sinus membrane is lifting through a crestal approach, characterized by the hydraulic detachment of the mucosa through injection of a liquid by its spontaneous expulsion or aspiration, and simultaneous filling of the sub Schneiderian space, with solid or semisolid grafting material. But this is involved in prolonging the operating procedure. Furthermore, during this conventional method, a single-use syringe is used which it is not possible to check exactly the progression of the membrane position [12]. In 2013, Andreasi et al. introduce a new method with the advancement of hydraulic pressure exercised on a semisolid graft material to detach the sinus membrane and simultaneously fill the augmented space created this way [19]. This technique is called as HySiLift. There were three components of instruments have used this purpose:

- 1) a titanium syringe equipped with a micrometric control piston on which it is possible to assemble disposable syringes of various volumes;
- 2) a surgical steel dispenser available in two forms (conical and cylindrical) and four diameters (two cylindrical of ϕ 3.2 and 4.0 mm and two conical of ϕ 2.8–4.0 and 3.5–4.6 mm) and;

3) a needle in surgical steel, with a Luer lock attachment, complementary to that of the single-use syringe.

The single-use syringes can be pre-loaded with the desired amount of graft material that, in our experience, was represented by nanocrystalline hydroxyapatite in an aqueous medium or the syringe containing the graft material as provided by the manufacturer. The tip of the titanium injector is semi-spherical shaped so that to penetrate nearly 3 mm in the sub-Schneiderian space without damaging the overlying mucosa while the lateral openings allow uniform distribution of the paste-like graft material while forming a dome precisely in correspondence to the future implant site. The threaded portion of the dispenser extends for an about 6 mm length, thus indicated for ridges of 3-6 mm thickness to ensure the sufficient stability of the tool during the injection maneuver.

Sinu-Lift System

This is a minimally invasive two-staged indirect sinus lift procedure called a "Sinu-Lift system" that utilizing beta-tricalcium phosphate in conjunction with platelet-rich plasma²⁰. The disposable kit consists of starter drill, curettes, and bone packer. The starter drill (\varnothing 3.2-mm) makes osteotomy towards the sinus membrane which disengages upon contact with the sinus membrane to avoid the rupture. The 3-mm yellow and 4.2mm blue curettes are used to gently separate and additional elevation of the membrane. The curettes with colour codings allow the accurate control of the working length providing the desired membrane elevation by minimizing the risk for membrane perforation and post-surgery infections. The bone packer is used to fill the space incrementally with pure phase synthetic β -TCP (Tricalcium phosphate) sized 500-1000 μ m mixed with PRP (Platelet Rich Plasma) was obtained by adding 1ml Batroxobin and 1ml of 10% Calcium gluconate). Mean duration of the procedure was 22.6 ± 7.5 min and the mean bone height at the desired area of sinus augmentation was 4.4mm which is also statistically significant ($p < 0.01$). Thus, it is appropriate to conclude that sinus-floor elevation using the "sinu-lift system" is definitely a reliable tool in achieving maximum sinus lift for augmentation [20].

Sinus Augmentation with Simultaneous Implant Placement

An osteotomy was started with a 2.8 mm drill to a depth of 3 mm using a stopper and guided with radiographs. The osteotomy was widened with two diameters under drilling off to the desired width (e.g. 3.2 mm for 4.2 mm; 3.65 mm for 5 mm). The sinus floor was opened by specially designed diamond tips with automatically prevent the Schneiderian membrane penetration. The length of the implant was selected based on the bone height: (a 13-mm for 5mm bone, 14.5-mm for 6.5 mm bone, and a 16-mm for 8 mm bone). Then the implant was inserted into the osteotomy until it reached the end of the prepared osteotomy and slowly advanced until the sinus floor was penetrated (<1 mm). A normal saline syringe was

connected to the implant via the tubing port. Saline solution (2 cc) was gently injected through the implant and into the sinus. After retracting the saline, the syringe was disconnected from the tubing port and flowable bone graft syringe was then connected. The bone graft material was then slowly injected through the implant into the sinus. After that, the bone graft syringe and the tubing port were disconnected from the implant [21]. Biphasic calcium phosphate in the suspension of a soluble polymer or β tricalcium phosphate granulate suspended in a hyaluronic acid matrix were used as injectable bone grafting materials. Then the implant was fully inserted through the osteotomy until the implant aligned with the alveolar crest [21].

According to the study done by Chaushu, et al. [21], the mean initial bone height was 4.21 ± 0.5 for the control and 5.44 ± 0.76 for the study group ($p < 0.01$). The mean bone gain for the study group was 7.80 ± 0.5 mm and 9.3 ± 0.5 mm for the control group ($p < 0.01$) and all the implants were placed during the study were osseointegrated at second-stage surgery.

Discussion

The sinus lifting is a mandatory element in managing atrophic edentulous posterior maxilla. The sinus augmentation procedures have been well established in clinical implant dentistry with many techniques and modifications. In 1980 Boyne and James performed >10mm bone augmentation through lateral approach in the atrophic maxilla with a significant higher post-surgical morbidity and an increased risk of membrane perforation. Therefore, Crestal approach, sinus lift surgery, may be performed with different bone-grafting materials, such as allograft, autogenous bone or heterologous materials, and platelet derivatives themselves or combined with grafting materials, in order to combine the properties of the growth factors that allow a better force control during the sinus floor elevation [12]. Compared to the lateral open approach, the indirect sinus lift technique has many advantages even though it is performed blindly. The advantages are, more conservative, less frequent of sinus membrane rupture, the possibility of simultaneous implantation, good bone healing, better positioning of bone grafting material, no subjected to resorption and high predictable implant survival rate [15]. Further, the 5-year survival rate of implants more to 92.7% in less than 5 mm ridge height and 94.9% for implants placed in more than 5mm ridge height after the indirect sinus lift technique [15]. The height bone in between crest of the alveolar bone and the floor of the sinus is the most important factor that influences the survival rate of the implants which placed in sinus augmented sites.

That fact is similarly important for the primary stability of the implants too. According to the literature the amount of available bone directly proportionates to the survival rate. Rosen, et al. [22] concluded that the survival rates are strictly linked to the residual bone height, starting from 96% when 5 mm or more of bone is present and dropping it into 85% when 4 mm or less bone is

present. A reduction of the grafted material has been evident over the first 3 months of bone remodeling and remained stable over the whole follow-up period (60 months)¹⁵. Regarding the grafting materials, several authors describing a consistent bone formation (6.51 mm ± 2.49 mm) even when no grafting material was used after a minimum of 1-year follow-up. On the other hand, some authors have suggested their necessity as the use of a blood clot or platelet concentrates alone may lead to unpredictable results [11]. The autologous bone grafting materials were representing the gold standard, however, might be subjected to extensive resorption and endosinus contamination due to intraoral pathogens [11]. However, the successful predictability of the indirect sinus lifting procedures are depending on several factors such as the amount of the remaining bone height, primary stability, the ability to elevate the Schneiderian membrane without any tearing, a low membrane detachment force, elasticity and deformation capacity, the amount of elevation, and number of implant insertion sites.

Conclusion

Gaining additional bone height in atrophic maxilla through sinus augmentation is a well-established clinical procedure in implant dentistry. Compared to the lateral approach technique the vast varieties of indirect sinus lifting techniques are available with more safety and predictable success rates when selecting the cases appropriate to the specific techniques.

Declarations

Ethical Approval and Consent to Participate

Not applicable

Consent for Publication

Not applicable

Availability of Supporting Data

All the gathered information were presented in the text.

Competing Interests

The author is declared that there is no conflict of interests on any materials or products which were described in the manuscript.

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