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Clinical Effectiveness of the Lateral Approach of the Maxillary Sinus Floor Augmentation using Different Gadgets with Simultaneous Implant Placement: A Systematic Review with Meta-Analysis

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Abstract

Objectives: Help the clinician to choose between the newly introduced, specifically designed instruments for this procedure. **Methods/Statistical Analysis**: after thorough search of Cochrane CENTRAL and PubMed databases, the analysis was limited to clinical studies of the lateral approach sinus augmentation with simultaneous implant placement. **Statistical Analysis:** Comprehensive Meta Analysis version 2.2.048 software was used. **Results:** Eight articles were included in the review. Analysis of the formatted tables shows that the type of tool used in sinus lateral approach might affect the success of the procedure. **Findings**: There was a statistical significance difference of using the ultrasonic tips over the conventional use of rotary tips but it is not usually to be clinically significant; especially if a highly trained surgeon could perform the lateral osteotomy by any tool but the previous studies were highly supporting the ultrasonic tips over the rotary tips in reference to less traumatic surgery with minimal operative and postoperative complications. **Application/ Improvements:** Randomized clinical trials are needed to compare the newly presented tools like DASK and SLA reamers to properly asses their clinical effectiveness. Studies of patient reported outcomes are needed to clearly evaluate the cost effectiveness of each tool.

Keywords: Augmentation, Implant, Lateral Approach, Maxillary Sinus, Simultaneous

1. Introduction

Damage of the membrane lining the maxillary sinus is the most common problem of the lateral approach sinus floor augmentation techniques which used as a corrective surgery to the upper posterior atrophic ridge with height problem that contradict implant placement at this site . Perforations were most likely accompanied with the use of traditional rotary tips and saws[1].

Recently different tools designed to minimize the possibility of sinus membrane tear .[2] Piezoelectric tips are ultrasonic auscultation tips that selectively cut the bone without damage of soft tissue and teeth[3,4].

Many reamers presented nowadays in the market which minimally invasive to the sinus membrane likes (Biomet 3i) but it was advised to be used with extreme caution[5]. LS and C reamers (SLA KIT, Neobiotech) are other types of drills of a conical trunk and specific penetration depth that selected for each case from the pre-operative cone beam volumetric tomography[6]. Moreover, it favors good accessibility to the surgical site; lessen the time of surgery when compared to the conventional rotary tips, also it considered of low cost when compared to the piezoelectric tips[7].

Altered type of reamers was presented that based on cutting the bone on the lateral surface of the maxillary

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sinus by thinning it gradually[8]. Also, there are new drills called Artificially Intelligent (AI- Water Lift System) that stops cutting the bone when they reach the membrane lining the sinus cavity by pressure sensitivity[9].

Implant placement could be simultaneous with the sinus floor augmentation or in staged approach, the former provides the advantages of shortening the time of treatment and less surgical entries, but it requires minimal residual preoperative bone height of 5mm that guaranties implant primary stability[10].

2. Material and Methods

2.1 Focus Question

Which is the best tool to be used in lateral sinus augmentation technique and to help clinicians choose between the newly introduced tools in the market? It established by PICO (Population, Intervention, Comparison Andoutcome).

Population: Patients with upper posterior edentulous area with insufficient bone height for implant placement.

Intervention: piezoelectric ultrasonic tips and reamers.

Comparison: Conventional rotary burrs.

Outcomes: implant survival and bone height changes

2.2 Type of Intervention

New tools which specifically designed for the lateral approach sinus floor augmentation technique.

2.3 Outcome Parameters

Outcomes to be assessed were membrane perforation, postoperative sinusitis, graft loss, implant survival rate, graft height reduction and postoperative bone height.

3. Study Type and Follow Up

Randomized clinical trials on patients (sample size = minimum 4 patients) need restoration of upper posterior edentulous area which complicated by sinus floor pneumatization; with residual bone height (at least 8 mm) requiring sinus floor augmentation via the lateral approach and simultaneous implant placement and at least follow up of 6 months after implant placement.

4. Exclusion Criteria

- In vitro studies.
- Case reports and case series studies.
- Implants survival rate not assigned in the paper or implant success not one of the outcomes.
- The technique of sinus augmentation not clearly described.

4.1 Search Strategy

A computerized systematic search strategy was conducted in Cochrane CENTRAL and PubMed searching for human studies with no language restrictions. The full text articles were obtained from reviews on sinus floor augmentation published to date. Additional publications were identified from the reference lists of the retrieved articles. No individual journal search was conducted but rather depending on reputable journals already indexed in the searched databases.

4.2 Search Combination

Search terms were ((((((sinus lift lateral) OR sinus lift lateral window) OR lateral sinus lift) OR external sinus lift) OR open sinus lift)) AND ((((simultaneous implant) OR implant placement) OR implants dental) OR implants)

4.3 Selection of Studies

Independent screening of all papers by the authors based on the inclusion criteria. The selected articles were then obtained in full text. Disagreements were resolved by discussion. PRISMA flow chart presented in Figure 1.

4.4 Data Extraction

The reviewers independently extracted the data using data extraction tables. Any disagreements were resolved by double-checking the original data and by discussion.

4.5 Quality Assessment

Retrospective studies were excluded because they are highly susceptible to recall bias so they considered of a low grade of evidence. Cochrane tool for risk of bias assessment was used to assess the quality of included clinical studies regarding sequence generation, allocation concealment, blinding, incomplete outcome data and selective outcome reporting .

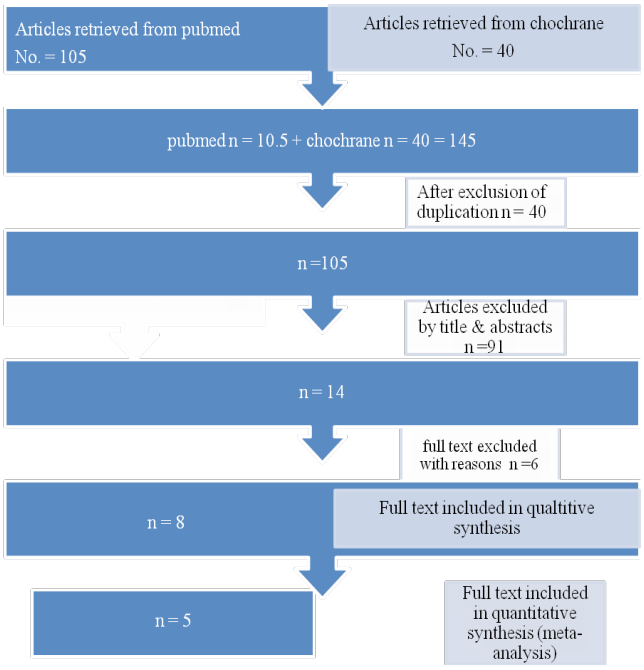

Figure 1. PRISMA flow chart.

Table 1. List of excluded articles

Authors	Reasons of exclusion
[9]	Case report
[10]	Two stages implant placement (not simultaneous with sinus augmentation)
[28]	Crestal approach not lateral approach
[29]	Crestal approach – two stages implant placement
[30]	Staged implant placement
[23]	Two stages implant placement not simultaneous with sinus floor augmentation

5. Results

105 articles were identified by electronic searching. Eight original articles fulfilled the inclusion criteria as in (Figure 1).After reading the full text (Table 1): Three articles were excluded because implant placement were in two stages after augmenting the sinus, two articles were excluded also

Table 2. Study design and basic patient data and exclusion characters

The author	Design of study	No. patients	No. sinuses	Age (years)	Mean of age	Smokers	Systemic disease	Sinus pathology	Others
[25]	Randomized clinical trial	10	15	35-58		No	Yes	Yes	periodontitis
[24]	Retrospective	17	Not specified	Not specified	51	> 10 cigarettes per day	Yes	Yes	previous maxillary sinus surgery
[14]	Randomized clinical trial	12	13	20–50		Not specified	Yes	Yes	Limited mouth opening
[11]	Retrospective	33	Not specified	Not specified	55	Not specified	Yes	Not specified	Not specified
[13]	Retrospective	49	49			Yes	Yes	Yes	Not specified
[26]	Retrospective	73	81	29 to 78	53.79 +- 9.92	No	Yes	Yes	previous sinus surgery
[27]	Not specified	10	12	Not specified	Not specified	Not specified	Yes	Yes	Replacement of the bone window not possible
[12]	two-arm and split-mouth randomized controlled clinical trial	104 and 5	135	39 to 81	64.9	No	Yes	Yes	Pregnancy

Table 3. Characters of surgical procedures

The authors	Residual bone height	Simultaneous/ Staged implant placement	Membrane use	The lateral osteotomy characters	Tool used for the lateral approach	Healing	Grafting	Implants
[25]	>5mm	Simultaneous	platelet-rich fibrin (PRF)	Not specified	ultrasonic tips	Loading after 6 months , 1 year postoperative ct	(MBCP) Biomatlante Inc., Vigneux de Bretagne, France	In-Kone TEKKA implants)
[24]	3.32 to 8.14mm	Simultaneous	No	bony window was used to cover the osteotomy site	a Piezo surgical tip or a number 4 diamond round bur	Follow up at 2 weeks, 4 weeks, and 4 months after the surgery for post surgical evaluation. Second stage surgery was scheduled at 5- to 6-month post sinus lift	calcium phosphate silicate (CPS) putty bone substitute (NovaBone Dental Putty; NovaBone Products, Alachua,fl)	(BioHorizons, Birmingham, AL)
[14]	>5mm	Simultaneous	collagen membrane	Window	3mm diameter round bur	Loading was 6 months after placement of implants.	Alloplastic bone graft (Bioactive glass putty)	Self-threaded, Tapering, Double thread, Acid etched and sand-blasted, selective Integrated surfaced Implants
[11]	5mm	Simultaneous	Not specified	trap-door, open-window	electric-motor drill	The prosthetic procedures of both 1-stage or 2-stage systems were started at 7 to 8 months and with initial force loading at about 9 months after sinus lifting-combined implant surgery. follow up to 2 years	Not specified	-(ITI; Straumann, Waldenburg,Switzerland, and SwissPlus; Centerpulse Dental, Carlsbad, CA) -(Friate-2; FriadentGmbH,Mannheim, Germany)
[13]	>3mm	Not specified	Collagen	Window	hand and piezo -surgery burs	12 months of follow up after delivery of crowns.	(MinerOss, BioHorizons, Birmingham, allograft	(Nobel Biocare, Zurich-Flughafen, Switzerland)

26	<6 mm	simultaneous or by staged approach	Collagen used only to seal over perforations	Not specified	Piezo-surgery burs	delayed implant loading	bone allograft (PUROS, Zimmer Dental Inc., Carlsbad, CA, USA)	(TSV, Zimmer Dental Inc.)
27	Mean = 3.07 +- 1.35 mm	Not specified	Not specified	replaceable bone window	oscillating saw (Aesculap®, B. Braun Melsungen AG, Germany)	Abutment connection surgery was performed after 6months of healing.	Not specified	(Brånemark System®, TiUnite™, Nobel Biocare AB, Gothenburg, Sweden)
12	range, 4–10 mm	When residual bone height was ≥4 mm, implants were placed simultaneously n =61	Porcine collagen (control group)	Boyne & James (1980) and Tatum (1986)	Not specified	Loading after 6 months after placement..	(Bio-Oss; Geistlich Pharmaceutical AG, Switzerland)	(Osseotite; Biomet 3i Inc., Palmbeach, FL, USA)

Table 4. Complications

The authors	Implant survival rate	Graft height reduction	Post-operative bone height	Sinus perforation	Postoperative sinusitis	Graft loss	Other
25	Not specified	1.7mm^3 Volume of bone graft material used, mean Correlation to new bone formed 0.079 mm^3	The volume of the new space created was 2.94 mm^3, 0.70 ml in the lateral sinus lift group and 3.40 mm^3 1.30 ml in the sinus infiltration technique group Height of the membrane elevation, mean =13.5 mm, Volume of new bone formed mean=2.94 mm^3	no	no	No	moderate edema
24	survival was 96.67% (29/30) during a mean follow-up of 15.74 months post loading.	Not specified	Mean 13.34 mm (61.74 mm) Difference 8.43 +- 2.08	no	Not specified	Not specified	Not specified
14	100 %	0.3–0.7 mm 1 year after loading 0.2–0.3 mm 2 years after loading	Increase in residual ridge height ranged from (71.43 to 133.33 %) 3.7–6.1 mm (on an average 4.5 mm).	One perforation, sealed by bio-absorbable membrane.	One patient	Not specified	Not specified

11	100%	Not specified	Increases in lifted sinus bone height ranged from 3 mm to 9 mm with an average of 4.5 mm.	No	No	Not specified	Not specified
13	100%	Not specified	Residual sinus floor/initial bone height Mean control group particulate graft = 5.09 mm and in test group Dynablast =4.66 mm	2 patients , small perforations , covered by collagen	Not specified	Not specified	Not specified
26	Not specified	Not specified	11.32 (+- 2.48) mm	Mean perforation = 17.28%	Not specified	Not specified	Not specified
27	100%	Not specified	Mean (4–10) mm	Not specified	Not specified	Not specified	Not specified
12	95.3%	Not specified	Average of new bone 19 mm (-+ 6) covered by collagen 15 mm (-+5) uncovered by membrane	Not specified	Not specified	4	Not specified

because the augmentation were from the crest of the ridge and one article was excluded because it was a case report.

5.1 Included Studies

Eight articles were included in this review and presented in Tables 2-7. Most of the excluded patients in the included studies were the patients with history of sinusitis, immune system disorders, and uncontrolled systemic diseases; also most of the included studies excluded the smoker patients (Table 3). The surgical technique was by trap door technique or an access hole (Table 4). In the included studies, all patients underwent the lateral approach sinus floor augmentation with simultaneous implant placement.

5.2 Quality Assessment (Risk of Bias Assessment)

One randomized clinical trial was of low risk of bias, one randomized clinical trial was of unclear risk of bias because of unclear sequence generation, allocation concealment, blinding, incomplete outcome data and selective outcome reporting, one randomized clinical trial was of high risk of bias. (Table 5).

5.3 Statistical Analysis

Meta-analysis is the last step in systematic review formulation which aimed for analysis of the studies by Comprehensive Meta Analysis version 2.2.048 software, after measuring the heterogeneity to decide on the fixed or random effects approach by Cochran's Q, which provides P-value of the studies, but I^2 is more reliable in assessing inconsistency between studies, with values of 25%, 50% and 75% corresponding to low, moderate and high heterogeneity respectively[11].

Meta-analysis done for changes in bone height used the Standard Difference in Means (SDM) as the effect measure, while meta-analysis for survival rates used the rate as the effect measure.

The publication bias was checked by Funnel plot. Egger's test of the intercept was used to quantify the display of the funnel plot.

6. Results

6.1 Survival Rate

Heterogeneity measures in Table 6 showed non-statistically significant Cochrane Q value (*P*-value = 1.000). I^2

Table 5. Cochrane collaboration's tool for risk of bias assessment

Author	Sequence generation	Allocation concealment	Blinding of participant, personnel and outcome assessor	Incomplete outcome data	Selective outcome reporting	Other sources of bias	Risk of bias
[25]	Unclear	Unclear	Unclear	Unclear	No	Unclear	Unclear
[14]	No	No	No	No	No	Unclear	high
[12]	Yes	Yes	Yes	Unclear	Unclear	No	Low

value was 0.0% indicating no heterogeneity. So we can conclude that homogeneity hypothesis is not rejected and the fixed effects model will be used.

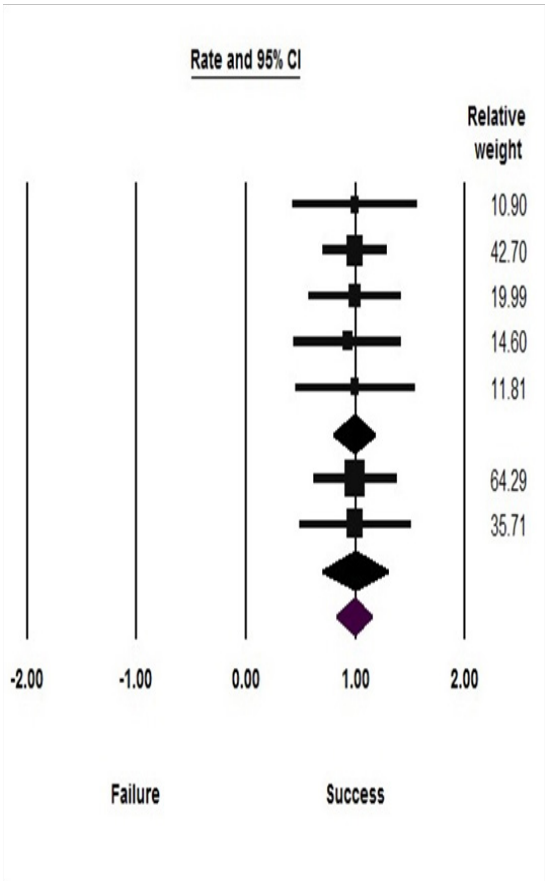

Figure 2. Forest plot for survival rate.

Table 6. Heterogeneity measures of meta-analysis for survival rate

	Value	Df	*P*-value
Cochrane Q	0.1	2	0.942
I^2	0.0%		

**: Significant at P ≤ 0.05, df: degrees of freedom (n-1)*

The fixed effects model **(Figure 2)** showed a survival rate (effect size) of 0.990 (99.0%) using conventional rotary tips and a survival rate of 1.000 (100.0%) using Ultrasonic tips. The overall survival rate is 0.993 (99.3%) and the effect size is statistically significant with *P*-value < 0.001.

The relative weight of the included studies, was the highest weight (30.9%)[12] while showed the lowest weight (7.9%)[13].

Funnel plot analysis for the included studies showed no publication bias. This was confirmed by Egger's regression intercept which showed non-statistically significant result (*P*-value = 0.548). As the results were not statistically significant, we concluded that there is no publication bias.

6.2 Changes in Bone Height

Heterogeneity measures shown in (Table 7) were statistically significant as Cochrane Q value (*P*-value < 0.001). I^2 value was 97.4% indicating high heterogeneity. So we can conclude that homogeneity hypothesis is rejected and the random effects model will be used.

The random effects model (Figure 4) resulted in standardized mean difference (effect size) of 0.376 using conventional rotary tips and 0.433 using ultrasonic tips. The overall change in bone height was in the direction of increase and the overall effect size was 0.410. The effect size was statistically significant with *P*-value < 0.001. So, we can conclude that there was a statistically significant change in bone height.

The relative weight of the included studies was the highest weight (50.6%)[14] while showed the lowest weight (32.7%)[15].

Funnel plot analysis for the included studies showed a publication bias. This was confirmed by Egger's regression intercept which showed a statistically significant result

Tool used	The Author	Statistics for each study						
		Rate	**Standard error**	**Variance**	**Lower limit**	**Upper limit**	**Z-Value**	**p-Value**
Rotary	27	1.000	0.289	0.083	0.434	1.566	3.464	0.001
Rotary	12	1.000	0.146	0.021	0.714	1.286	6.856	0.000
Rotary	25	1.000	0.213	0.045	0.582	1.418	4.690	0.000
Rotary	24	0.933	0.249	0.062	0.444	1.422	3.742	0.000
Rotary	14	1.000	0.277	0.077	0.456	1.544	3.606	0.000
Rotary Rotary		0.990	0.095	0.009	0.803	1.177	10.389	0.000
Ultrasonic	15	1.000	0.192	0.037	0.623	1.377	5.196	0.000
Ultrasonic	24	1.000	0.258	0.067	0.494	1.506	3.873	0.000
Ultrasonic		1.000	0.154	0.024	0.698	1.302	6.481	0.000
Overall		0.993	0.081	0.007	0.834	1.152	12.245	0.000

(*P*-value = 0.030). As the results were statistically significant, we concluded that there was a publication bias.

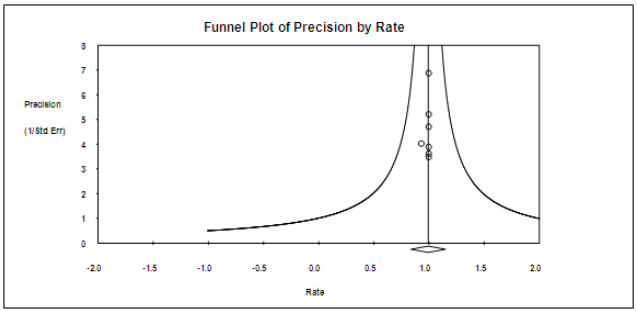

Figure 3. Funnel plot for survival rate.

Table 7. Heterogeneity measures of meta-analysis for change in bone height (Group 2)

	Value	**Df**	***P*-value**
Cochrane Q	154.9	4	<0.001*
I^2	97.4%		

**: Significant at P ≤ 0.05, df: degrees of freedom (n-1)*

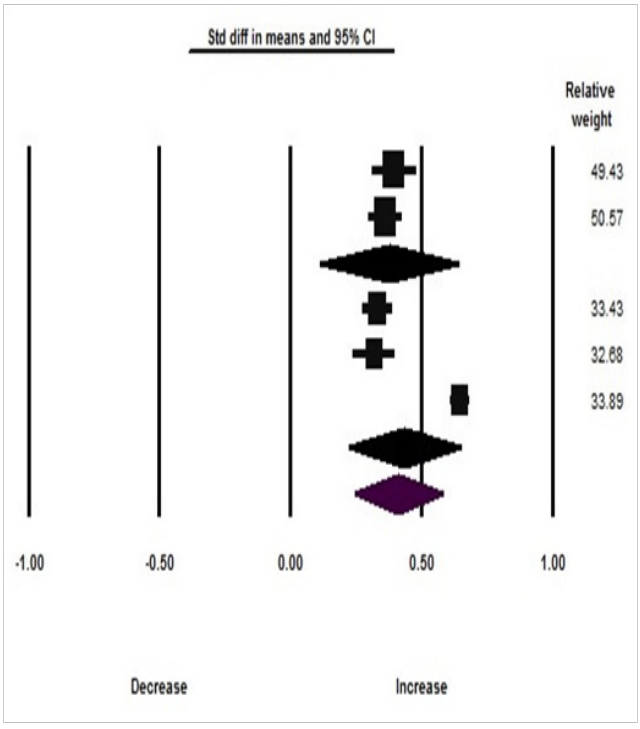

Figure 4. Forest plot for change in bone height.

7. Discussion

Many surgical tools designed recently aimed for minimizing the sinus trauma possibilities .[16] Inthe contrast, some studies showed non-significant difference between piezoelectric tips and conventional rotary tips[17], also some authors claimed that membrane perforation not correlate with implant survival[18].

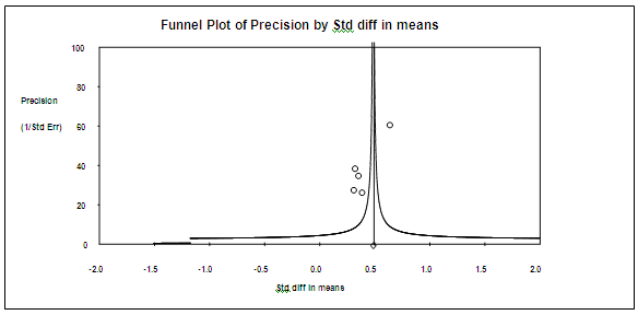

Figure 5. Funnel plot for change in bone height.

When comparing the piezoelectric tips with the conventional rotary tips, regarding the incidence of perforation was lowered from 7%[19] to 3.8%[20] while by conventional rotary tips was from 11%-56%[21]. Investigating the effect of the piezoelectric patch length on the required control voltage was the interest of recent engineering research[22].

Regarding the operative time it was increased using piezoelectric tips and the rotary tips .other studies used the new reamers didn't measure the time, so more randomized clinical trials are needed which measure the time one of the outcomes. Post-operative sinusitis as an expected complication after the lateral approach sinus floor augmentation was not founded when ultrasonic tips used[23], it was founded in one patient by using 3mm round burr[24] and not specified in the rest of the included studies.

Regarding the implant survival rate which is the primary patient related outcome was 96.67% (29/30) during a mean follow-up of 15.74 months post loading, 95.3%, 100% when round burr used or electric motor drill or either use of hand or piezoelectric rotary tips or by using oscillating saw which means that survival implant rates not correlate to the tool used for the sinus augmentation and was not specified in the rest of studies[25]

Graft loss was seen in four patients, not found when ultrasonic tips used, and was not specified in the other included studies[26] on the contrast the reduction of graft was 0.3–0.7 mm in height 1 year after loading and 0.2–0.3 mm 2 years after loading when 3mm round burr used but it was not clearly specified or calculated in the rest of the included studied[27].

8. Conclusions

The retrieved evidence provides a statistical significance difference of using the ultrasonic tips over the conventional use of rotary tips but it is not usually to be clinically significant; especially if a highly trained surgeon could perform the lateral osteotomy by any tool also the perforation of the sinus could be managed easily especially if it of small size by covering it by collagen barrier or by suturing if it was of large size and accessible one , but the previous studies were highly supporting the ultrasonic tips over the rotary tips in reference to less traumatic surgery with minimal operative and postoperative complications. Clear reasons identified that should prompt the clinician to prefer ultrasonic tips or rotary tips or any other type of tools. Randomized clinical trials are needed to compare the newly presented tools like DASK and SLA reamers to properly asses their clinical effectiveness. Studies of patient reported outcomes are needed to clearly evaluate the cost effectiveness of each tool.

9. Conflict of Interest

The authors declare no conflict of interest. The authors don't have financial interests in the products or tools listed in the review.

10. Acknowledgment

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11. References

1. Hernández-Alfaro F, Torradeflot MM, Marti C. Prevalence and management of Schneiderian membrane perforations during sinus-lift procedures. Clin Oral Implants Res. 2008; 19:91–8. PMid:17961185
2. Shin HI, Sohn DS. A method of sealing perforated sinus membrane and histologic finding of bone substitutes: a case report. Implant Dent. 2005; 14:328–33. PMid:16361881. Available from: Crossref
3. Vercellotti T, De Paoli S, Nevins M. The piezoelectric bony window osteotomy and sinus membrane elevation: introduction of a new technique for simplification of the sinus augmentation procedure. Int J Periodontics Restorative Dent. 2001; 21:561–7. PMid:11794567.
4. Rickert D, Vissink A, Slater JJRH, Meijer HJA, Raghoebar GM. Comparison between conventional and piezoelectric surgical tools for maxillary sinus floor elevation. A randomized controlled clinical trial. Clin Implant Dent Relat

Res. 2013 Apr; 15(2):297–302. PMid:21745325. Available from: Crossref
5. Emtiaz S, Caramês JM, Pragosa A. An alternative sinus floor elevation procedure: Trephine osteotomy. Implant Dent. 2006; 15:171–7. PMid:16766900. Available from: Crossref
6. Farré-Pagés N, Augé-Castro ML, Alaejos-Algarra F, Mareque-Bueno J, Ferrés-Padró E, Hernández-Alfaro F. A novel trephine design for sinus lift lateral approach. Case report. Med Oral Patol Oral Cir Bucal. 2011; 16:79–82. Available from: Crossref
7. Kazancioglu HO, Tek M, Ezirganli S, Mihmanli A. Comparison of a novel trephine drill with conventional rotary instruments for maxillary sinus floor elevation. Int J Oral Maxillofac Implants. 2013; 28:1201–6. PMid:24066309. Available from: Crossref
8. Lozada L, Goodacre C, Aladdin J, GarbaceaA. Lateral and crestal bone planingantrostomy: A simplified surgical procedure to reduce the incidence of membrane perforation during maxillary sinus augmentation procedures. J Prosthet Dent. 2011; 105:147–53. Available from: Crossref
9. Kim Y, Itoh Y, Kang TH. Evaluation of the effectiveness of a water lift system in the sinus membrane-lifting operation as a sinus surgical instrument. Clinical Implant Dentistry and Related Research. 2012 Aug; 14(4):585–94. PMid:20586782. Available from: Crossref
10. Cha HS, Kim A, Nowzari H, et al. Simultaneous sinus lift and implant installation: Prospective study of consecutive two hundred seventeen sinus lift and four hundred sixty-two implants. Clin Implant Dent Relat Res. 2014 Jun; 16(3):337–47. PMid:23157674. Available from: Crossref
11. Meloni SM, Jovanovic SA, Lolli FM, Cassisa C, et al. Grafting after sinus lift with anorganic bovine bone alone compared with 50:50 anorganic bovine bone and autologous bone: results of a pilot randomised trial at one year. Br J Oral Maxillofac Surg. 2015 May; 53(5):436–41. PMid:25796408. Available from: Crossref
12. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta analyses. BMJ. 2003; 327(7414):557–60.
13. Chen T, Chang H, Leung K, Lai Y, Kao S. Implant placement immediately after the lateral approach of the trap door window procedure to create a maxillary sinus lift without bone grafting :A 2-year retrospective evaluation of 47 implants in 33 patients. J Oral Maxillofac Surg. 2007; 65:2324–8. PMid:17954333. Available from: Crossref
14. Irinakis T. Efficacy of injectable demineralized bone matrix as graft material during sinus elevation surgery with simultaneous implant placement in the posterior maxilla: clinical evaluation of 49 sinuses. J Oral Maxillofac Surg. 2011; 69:134–41. PMid:21050634. Available from: Crossref
15. Jodia K, Sadhwani B, Parmar S, Anchlia S, Sadhwani S. Sinus elevation with an alloplastic material and simultaneous implant placement: A 1-stage procedure in severely atrophic maxillae. J Maxillofac Oral Surg. 2014 Jul-Sep; 3(3):271–80. PMid:25018600 PMCid:PMC4082555. Available from: Crossref
16. Al-Salman W, Almas K. Maxillary sinus and success of dental implants: an update. Gen Dent. 2015 Jul-Aug; 63(4):47–54. PMid:26147168.
17. Barone A, Santini S, Marconcini S, Giacomelli L, Gherlone E, Covani U. Osteotomy and membrane elevation during the maxillary sinus augmentation procedure: A comparative study: Piezoelectric device vs. conventional rotative instruments. Clin Oral Implants Res. 2008; 19:511–5. PMid:18371101. Available from: Crossref
18. Fermergård R, Astrand P. Osteotome sinus floor elevation and simultaneous placement of implants: A 1-year retrospective study with Astra Tech implants. Clin Implant Dent Relat Res. 2008; 10:62–9. PMid:18254742. Available from: Crossref
19. Wallace SS, Mazor Z, Froum SJ, Cho SC, Tarnow DP. Schneiderian membrane perforation rate during sinus elevation using piezo surgery: Clinical results of 100 consecutive cases. Int J Periodontics Restorative Dent. 2007; 27:413–9. PMid:17990437.
20. Blus C, Szmukler-Moncler S, Salama M, Salama H, Garber D. Sinus bone grafting procedures using ultrasonic bone surgery: 5-year experience. Int J Periodontics Restorative Dent. 2008 Jun; 28(3):221–9. PMid:18605597.
21. Nkenke E, Schlebel A, Schultze-Mosgau S, Neukam FW, Wiltfang J. The endoscopically controlled osteotome sinus floor elevation: A preliminary prospective study. Int J Oral Maxillofac Implants. 2002 Jul-Aug; 17(4):557–66. PMid:12182299.
22. Ali Nikkhoo, Amankhani M, Ghafari H. Vibration suppression in smart thin beams with piezoelectric actuators under a moving load/mass accounting for large deflections of the base structure. Indian Journal of Science and Technology. 2014; 7(2):211–20.
23. Kim SH, Hong K. Histologic evaluation of low-intensity pulsed ultrasound effects on bone regeneration in sinus lift. J Periodontal Implant Sci. 2010; 40:271–5. PMid:21246017 PMCid:PMC3021167. Available from: Crossref
24. Kher U, Mazor Z, Stanitsas P, Georgios A. Implants placed simultaneously with lateral window sinus augmentation using a putty alloplastic bone substitute for increased primary implant stability: A retrospective study. Implant Dent. 2014; 23:496–501. Available from: Crossref
25. Bensaha T, El Mjabber H. Evaluation of new bone formation after sinus augmentation with two different methods. Int J Oral Maxillofac Surg. 2016 Jan; 45(1):93–8. PMid:26427784. Available from: Crossref
26. Lin Y, Yang Y, Wen S, Wang H. The influence of sinus membrane thickness upon membrane perforation during

lateral window sinus augmentation. Clin Oral Implants Res. 2016 May; 27(5):612–7. PMid:26076580. Available from: Crossref

27. Lundgren S, Andersson S, Gualini F, Sennerby L. Bone reformation with sinus membrane elevation: a new surgical technique for maxillary sinus floor augmentation. Clin Implant Dent Relat Res. 2004; 6(3):165–73. Available from: Crossref
28. Li J, Lee K, Chen H, Ou G. Piezoelectric surgery in maxillary sinus floor elevation with hydraulic pressure for xenograft and simultaneous implant placement. J Prosthet Dent. 2013; 110:344–8. PMid:24084145. Available from: Crossref
29. Soltan M, Smiler D. Trephine bone core sinus elevation graft. Implant Dent. 2004 Jun; 13(2):148–52. PMid:15179091. Available from: Crossref
30. Erdem NF, Çiftçi A, Acar AH. Three-year clinical and radiographic implant follow-up in sinus-lifted maxilla with lateral window technique. Implant Dent. 2016 Apr; 25(2):214–21. PMid:26579850. Available from: Crossref