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Comparative Analysis Of Survival Rate Of Conventional Implant Placement Vs Computer Guided Implant Placement: A Systematic Review And Meta-Analysis

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ABSTRACT

Implant industry has evolved in terms of various technology and concepts that is beneficial for the dental field. The placement of implant prosthetically involves a lot of precision . Freehand implant placement requires adequate human skill set, whereas the computer guided requires a specific technology. Therefore, the survival rate involved in both the implant placement technique needed a detailed study. Therefore, this systematic review was undertaken to evaluate the survival rate of conventional implant placement vs the computer guided implant placement. A detailed data search was done on google scholar and PubMed and following which the results were tabulated. Both the conventional and computer guided implant placement showed no statistically significant result in comparison to the survival rate.

Keywords: *Dental implants; Conventional Implant Placement; Computer Guided Implant Placement; Survival rate; Flap technique; Flapless Technique.*

INTRODUCTION

Dental implants have evolved for years and have been effective replacement solutions in the field of dentistry. Various strategies were practiced for the placement of dental implants. With the advancement in technology computer-guided implant placement has a greater level of precision and accuracy.

Conventional, also known as freehand implant placement, relies specifically on a clinician's expertise and has been a gold standard in implant dentistry. These involve various steps right from the radiographic diagnosis, mock-up, and surgical stent fabrication in determining its placement and angulation. However, a freehand implant placement involves a greater success rate but with the potential risk of human error.

In comparison to the conventional method, the progress in computer-guided technology has a good alternative in terms of surgical correctness and efficiency. The surgical approach in computer-guided placement involves preoperative planning, virtual implant placement, and fabrication of surgical guides customized to the patient's anatomical bone and mucosa. The surgical technique involves fewer complications in pain and discomfort, reducing treatment time, and functional outcomes. However, the computer guides have their drawback in terms of excessive instrumentation cost, and specialized training of an individual.

Survival of the implant is crucial in terms of the technique used i.e. computer-guided or freehand implant placement. The implant position, angulation, accuracy of implant placement, and skills of an operator are the various factors to be considered for the survival of the implant.

The second most important thing is the surgical procedure that involves implant placement with a flap or the flapless technique used in both freehand and computer-guided implant placement. The flap technique involves the surgeon's manipulation skills, greater duration of healing, and patient compliance. Whereas the flapless technique involves less time, duration of healing, and better comfort in patient's post-operative surgically. Therefore, the consensus regarding this detailed description of implant survival as well as the surgical technique involved is at sparse.

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Therefore, our systematic review and meta-analysis seek to address the comparison between the implant survival percentage as well as surgical technique involved in placement when compared to computer guided technique and freehand technique.[1]

METHODOLOGY

The survival rate of dental implants is a key measure of its favorable outcome in prosthetic dentistry, especially when comparing different implant placement techniques. Two commonly use methods for implant placement are computer-guided and conventional traditional freehand techniques, each of which can be further studied based on whether a flap or flapless technique is used. Hence, this systematic review is designed to measure the survival rate of computer-guided and freehand implant placements using flap and flapless techniques. To determine the relevant studies databases like Google Scholar and PubMed were utilized. A Prospero registration was done CRD42024541428.

The main aim of this research is to know the survival percentage of implant placements using computer-guided and traditional free-hand methods, providing a broader overview to support evidence-based decision-making for dentists in implant placement and rehabilitation. When the investigation was only getting started, using various combinations of keywords including “Implant Survival rate”, “Computer guided implant placement”, “Freehand implant placement”, “Flap techniques”, “Flapless technique” and Boolean operators [OR, AND, NOT], asterisks (*), and quotation marks (“”) were also used to refine the search. This process yielded 52 articles published in various journals that were included in conducting the meta-analysis. The search process, including the application of search strings and filters, is detailed in Fig1., which outlines the systematic review steps undertaken for the meta-analysis.

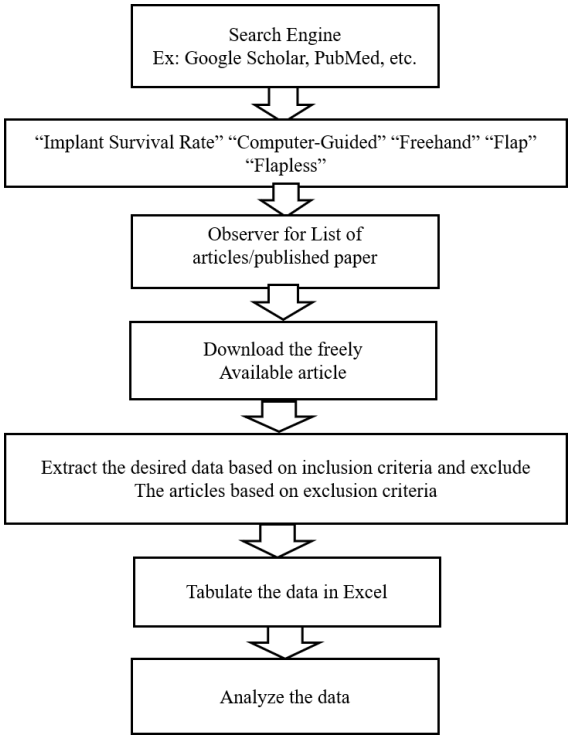
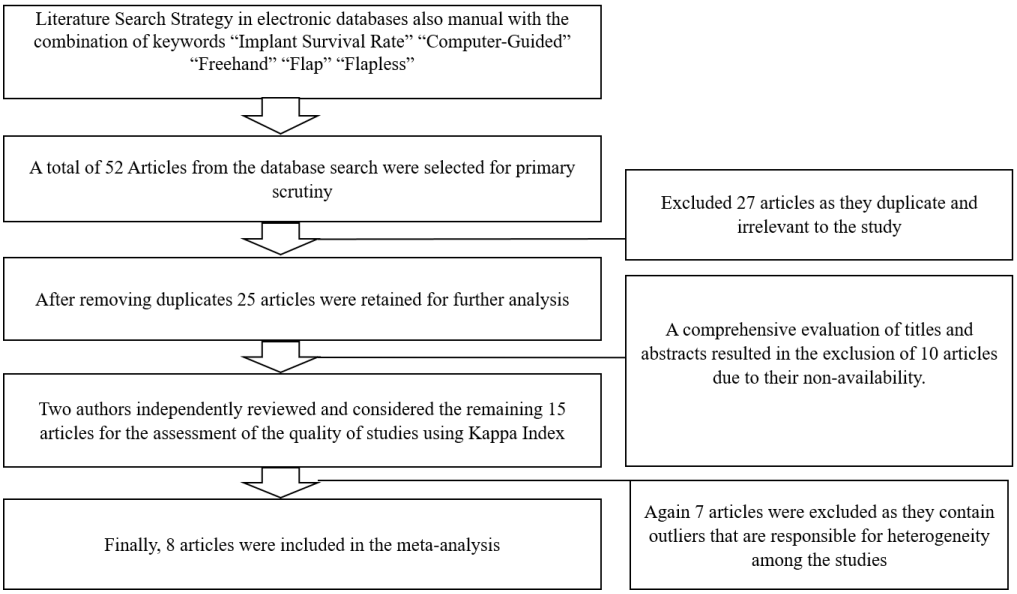


Fig. 1: Flowchart of search strings and filters like Google Scholar

For this comprehensive investigation into the survival rates of dental implants placed using computer-guided versus freehand techniques with both flap and flapless approaches, we used 5.0 and Rayyan QCRI to streamline the systematic review process. These web applications were instrumental in organizing and analyzing the data efficiently. We also conduct a thorough back-reference search, meticulously reviewing the reference lists of selected studies to identify additional relevant research. The primary aim was to evaluate the survival rates of implant placement using computer-guided versus traditional freehand techniques and to compare the outcomes of flap versus flapless approaches. Patients often have preferences based on various factors including their comfort, accuracy, recovery time, minimal invasiveness, and cost consideration, etc. Computer-guided methods and flapless techniques may favor for their precision and reduced discomfort while traditional freehand flap techniques may still prefer for their flexibility and should be discussed thoroughly. Therefore, this systematic review provides strong assessment of implant survival

rates and supports empirical-based clinical decision-making.

The literature search covered 52 articles from databases such as Google Scholar and PubMed for their comprehensive coverage of research. After removing duplicate and irrelevant studies, 25 articles were selected for detailed review. A thorough evaluation of titles and abstracts led to the exclusion of 10 articles. Two authors then independently assessed the quality of the remaining 15 articles. Ultimately 8 articles were included in the meta-analysis. Resulting in a refined dataset for assessing the survival rates of implants using computer-guided and freehand techniques with flap and flapless approaches.



We conducted a meta-analysis to assess the survival rates of dental implant placements using computer-guided and freehand techniques, with both flap and flapless approaches. Statistical analysis was carried out by utilizing R software version 4.2.2. Forest plots were created to visualize effect sizes, including confidence intervals to represent these estimates. To address variability and inconsistency I2 among the studies, both fixed and random effect models were utilized. The random effect model was used when significant heterogeneity and inconsistency were observed, accounting for differences across the studies included. The estimate of between-study variance (τ^2) was computed using the most conservative probability method to ensure a thorough and reliable assessment of implant survival rates.

Meta-regression was conducted using R software version 4.2.2 to investigate how different study characteristics influenced implant survival rates for computer-guided versus traditional freehand techniques, as well as flap versus flapless approaches. This analysis included a detailed subgrouping analysis across various clinical settings and groups to evaluate the impact of various parameters on implant survival. Among the important factors assessed were a evaluated included a survival percentage and implant techniques which could introduce potential bias. The primary aim was to measure the extent of heterogeneity among the studies included. Given the observed heterogeneity and the limited number of studies, a random effect model was employed to manage the variability in the outcomes.

We studied how various factors based on patients comfortness, accuracy, recovery time, minimal invasiveness, cost, etc. influence the results. Regression coefficients were calculated to determine the correlation between study characteristics and implant survival rates. Variables such as sample size, comparison techniques, and implant systems were considered for meta-regression, with those showing a p-value below 0.05 selected for the analysis. Factors demonstrating statistical significance ($p \leq 0.05$) were highlighted, providing clear insights into the average survival rate of implants placed using computer-guided versus freehand techniques, and flap and flapless approaches.

Subgrouping Analysis

A subgroup analysis was performed to compare the survival rates of dental implants placed using computer-guided and traditional freehand techniques, with both flap and flapless approaches. The study population was divided into smaller groups based on variables such as implant placement techniques, flap versus flapless methods, and other relevant factors. This approach aimed to determine of the survival rates of implants varied across different subgroups.

The analysis enabled us to identify the factors that could influence implant survival rates. For instance, we explore how differences in techniques utilized, implant systems, or patients' preferences might impact the overall outcomes. By examining these groups, we gained insights into the specific conditions under which computer-guided and freehand techniques as well as flap a flapless approach, are most effective. This understating helps in developing more tailored and effective strategies for implant placement, enhancing overall treatment success.[2]

RESULTS

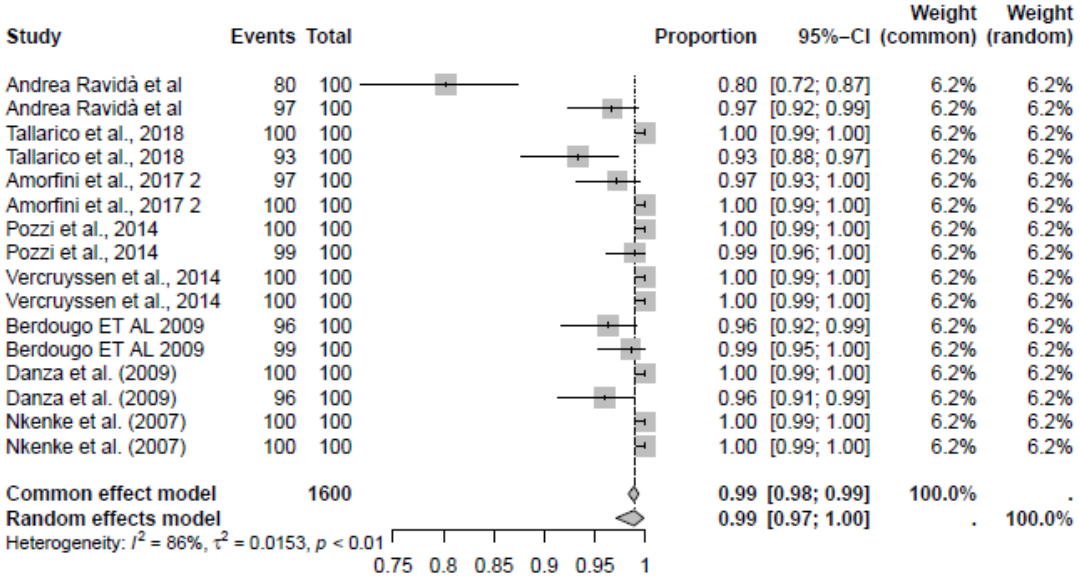


Fig 3: Forest plot for the studies included

The funnel plot (Figure 4) reveals the potential publication bias, with slight asymmetry indicating that smaller studies might report different effects compared to larger ones. To address this possible bias, we conducted a meta-regression using sample size as a proxy for bias risk. The analysis found no significant impact of publication bias ($p > 0.05$), indicating it did not substantially affect our findings. However, our meta-regression analysis did reveal significant heterogeneity in survival rates of implants placed using computer-guided versus freehand techniques, and flap versus flapless approaches. This led us to examine potential factors contributing to the variability in outcomes most closely. We conducted univariate meta-regression to assess the influence of factors like sample size, implant techniques, and methods. The meta-regression results identified significant covariates contributing to the observed heterogeneity. Key factors included sample size (regression coefficient for events: Qm = 5175.20 $p < 0.0001$), the survival rates of implants placed using computer-guided versus freehand techniques, and flap versus flapless approaches (Qm = 1617.97, $p < 0.0001$), as shown in Table 1. In conclusion, the findings highlighted the importance of subgroup analyses to improve the accuracy of the reported survival percentage of implants placed using computer-guided and traditional freehand techniques with flap and flapless. This analysis is crucial for understanding how variations in implants placement techniques, and also helps to know the average percentage of survival rate of both techniques along with flap and flapless approaches.

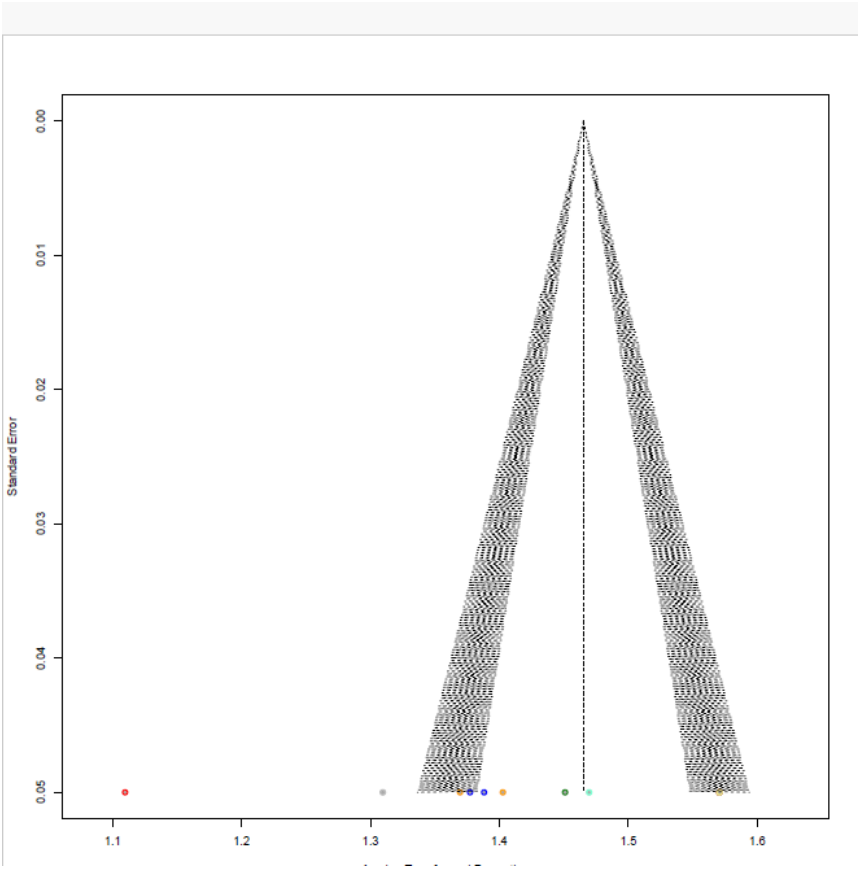


Fig 4: Publication bias among the studies included

Group	Particulars	SE	Z-Value	EST [95%.CI]	QM	P-Value
Sample size	High	0.02	62.34	1.53[1.48-1.58]	5175.20	<0.0001
	Low	0.03	35.88	1.31[1.24-1.38]		
Test	Compute Guided (Flap)	0.08	18.00	1.51[1.34-1.67]	1617.97	<0.0001
	Computer guided (Flapless)	0.06	22.09	1.43[1.31-1.56]		
	Freehand (Flap)	0.05	24.70	1.47[1.35-1.58]		
	Freehand (Flapless)	0.10	13.97	1.44[1.23-1.64]		

Table 1: Meta-regression

Stratification Results

Analyzing the survival rate of dental implants placed using computer-guided versus freehand techniques, and flap and flapless approaches reveals variations across the studies included. The studies with a low average survival rate of 93% (95% CI: 87%-98%, I2 =82, $\tau 2 = 0.00$, $p<0.01$), while those low average survival rate of 99% (95% CI: 99%−100%, I2 = 36, $\tau 2 = 0.00$, $p=0.11$), respectively (Table 2 & Fig 5). These variations underscore the influence of factors such as pain origin and potential confusion between maxillary and mandibular arches on the treatment outcomes. These findings help to enhance treatment efficacy and patients' greater sample size research is preferred to be more accurate rather than smaller sample sizes.

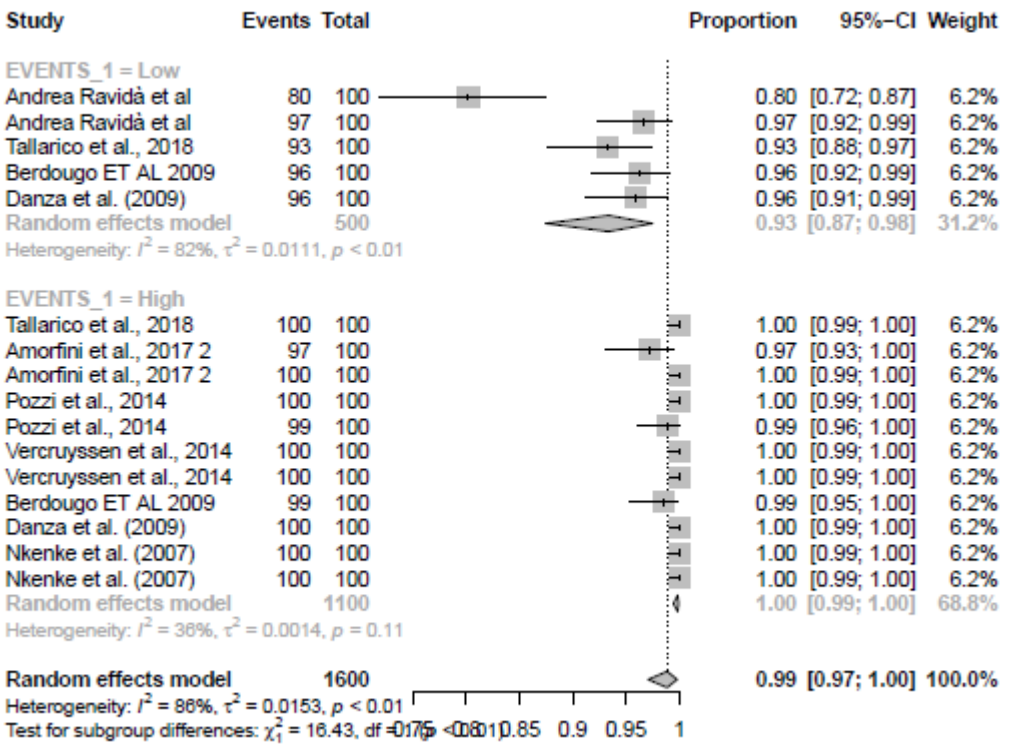


Fig 5: Forest plot portrays subgrouping of the percentage of survival rate

Evaluating the survival rate of dental implants placed using computer-guided versus freehand techniques, and flap and flapless approach, reveals notable variations. The survival rate of implants placed using computer-guided (Flapless) with an average percentage of 98% (95% CI: 91%−100%, I2 =94, τ2 = 0.03, p<0.01), Freehand (Flap) with an average percentage of 99% (95% CI: 97%−100%, I2 =67, τ2 = 0.01, p=0.01), Freehand (Flapless) with an average percentage of 98% (95% CI: 97%−100%, I2 =67, τ2 = 0.00, p=0.01) and computer-guided (Flap) with an average percentage of 100% (95% CI: 97%−100%, I2 =73, τ2 = 0.00, p=0.01), respectively (Table 2 & Fig 6). This outcome highlights that all techniques and approaches are highly effective, with survival rates generally exceeding 95%. The perfect survival rate observed with computer guided (Flap) techniques suggests that this might offer superior and more reliable. The low variability in survival rates within most groups indicates consistent outcomes. Although the slightly higher survival rates associated with computer-guided techniques could reflect their advanced features. Overall, while all methods are successful, the data suggests that computer-guided techniques, particularly with flap approaches, may provide slightly better outcomes, underscoring their potential advantages in implant placement (Table 2 & Figure 6).

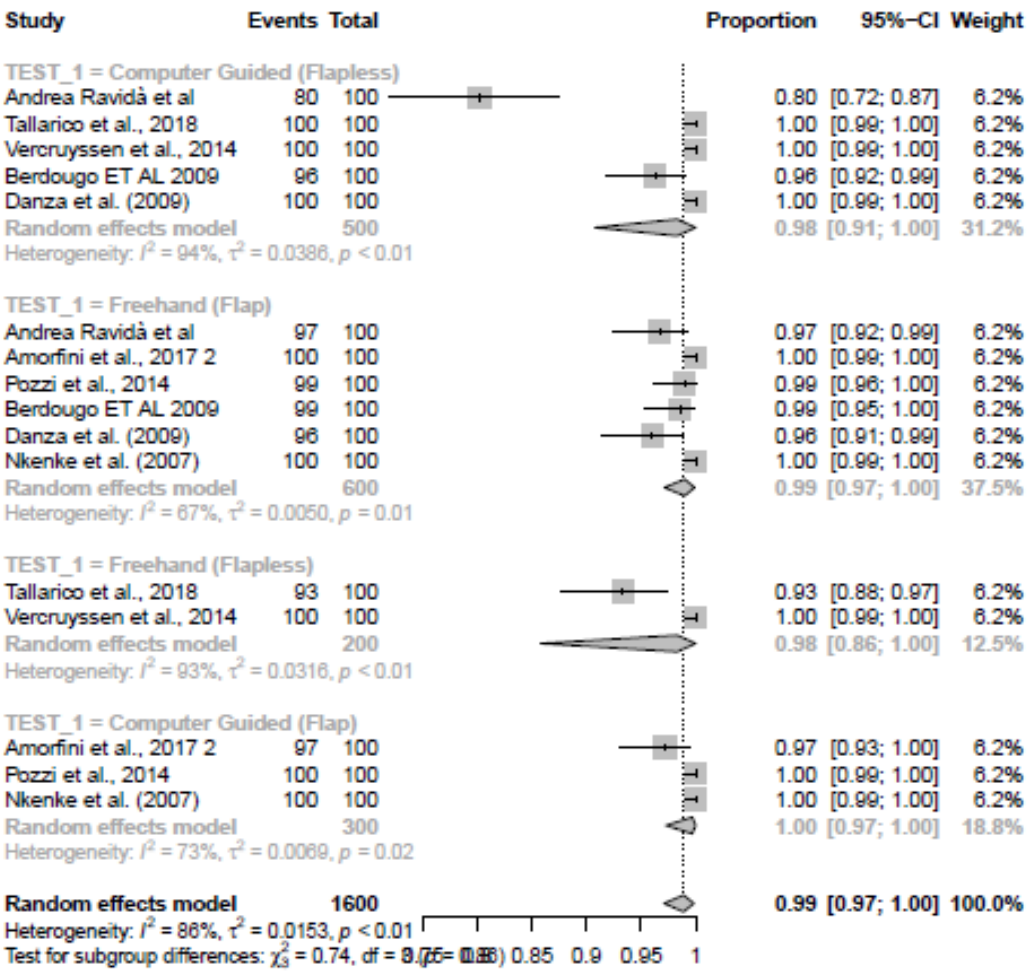


Fig 6: Forest plot portrays subgrouping of both computer-guided & freehand technique

Group	Sub - Group	I^2 %	C^2 %	P - Value	Survival Rate (%)	95% CI
Events	Low	82	0.01	<0.01	93	[0.87-0.98]
	High	36	0.00	0.11	100	[0.44-0.89]
Detection techniques	Compute Guided (Flap)	73	0.00	0.02	100	[0.97-1.00]
	Computer guided (Flapless)	94	0.03	<0.01	98	[0.91-1.00]
	Freehand (Flap)	67	0.00	0.01	99	[0.97-1.00]
	Freehand (Flapless)	93	0.31	<0.01	98	[0.86-1.00]

Table 2: *Stratification pattern: An In-depth explanation of various factor variations using sub-group analysis*

DISCUSSION

To the best of our knowledge, this was the first time we investigated and provided a comprehensive assessment of the survival rate of dental implants placed using computer-guided versus freehand techniques, and flap and flapless approach. This comprehensive review makes a substantial contribution to the field by comparing these widely used computer-guided and freehand techniques with flap and flapless approaches. Another study was done on 45 patients with 149 implants in the test group which included the computer-guided implant placement and 111 implants in the control group which included freehand implant placement with a minimum follow-up of 5 years found that an average mean follow-up of 9.6 years. The outcomes showed that there was no significant difference between the two groups (Ravida et al)[3].

In another study by Tallarico et al.2017 conducted on 10 patients in each group, 32 implants were placed using computer-guided methods and 30 using freehand techniques. No prostheses failed, but two implants failed in the freehand group (6.6%) compared to none in the computer-guided group (p=0.158). The results revealed that groups rate of complication were comparable, with no statistically significant differences in implant failure or complications.[4]

Whereas, one study placed 70 implants of which 36 were in the test group and 34 were in the control group. Test participants displayed statistically significant improvements in the patient's self-confidence, reduced use of painkillers, and perceived pain. Additionally, the test group that is the surgical guided experienced shorter surgery times and quicker provisions inserted in contrast to the group under control that included the open flap surgery ($p<0.05$) (Amorfine et al.2016).[5]

Yet another study by Pozzi et al.2014 with 26 patients receiving conventional treatment and 25 undergoing computer-guided rehabilitation, no patients dropped out. One provisional prosthesis failed in the conventional group, while the computer-guided had six complications among the five patients. There is no significant difference between the two groups it showed.[6]

Another study conducted suggested total survival rate throughout time was 98.57% in the control group which includes the conventional procedure and 96.30 in the test group includes the image-guided system flapless protocol. Whatever the statistical methods used, no statistically significant differences were found between the two techniques. The survival rate for transmucosal implant placement was 97%. Despite less favored initial conditions, the group's survival rate was compared to that of the standard protocol group (Berdougo et al).[7]

According to Danza M et al, and Nkenke E et al, the computer-guided has a better result than the conventional as supported by our systematic review also.[8,9] Whereas according to Vercruyssen M et al, the computer-guided and conventional did not show any much difference after a one-year follow-up study.[10]

Our study results are in line this study found the survival rate of implants placed using computer-guided (Flapless) with an average percentage of 98%, Freehand (Flap) with an average percentage of 99%, Freehand (Flapless) with an average percentage of 98% and computer-guided (Flap) with an average percentage of 100%, respectively. This outcome highlights that all techniques and approaches are highly effective, with survival rates generally exceeding 95%. The perfect survival rate observed with computer-guided (Flap) techniques suggests that this might offer superior and more reliable. The low variability in survival rates within most groups indicates consistent outcomes.

CONCLUSION

With the above discussion our study aimed to perform comprehensive investigation for survival rates of dental implants placed using computer-guided versus freehand techniques with both flap and flapless approaches, the results revealed that by comparing the computer-guided and freehand implants placements using flap and flapless approaches had no significant differences were observed by utilizing two methods in out outcome. However, patients who underwent freehand implant placements may experience some pain and swelling post operative in comparison with computer-guided placements using flap techniques. This may have chances to increase discomfort was primarily attributed to the more frequent elevation of flaps during the freehand procedure, which is less common in computer-guided implant surgery. The use of implant placement by utilizing computer-guided methods may help minimize the need for invasive procedures like flaps, potentially leading to a more comfortable recovery for patients.

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