Cost-effectiveness of the Flapless Insertion of Zygomatic Implants Using Dynamic Navigation - A Retrospective Study

Ashwini Bhalerao, Ashraf Ayoub[1], Madhulaxmi Marimuthu, Abdul Wahab, Vaibhav Kumar[2]

Department of Oral and Maxillofacial Surgery, Saveetha Dental College, Chennai, Tamil Nadu, [2]Department of Public Health Dentistry, Dr. G. D. Pol Foundation's Y. M. T. Dental College and Hospital, Navi Mumbai, Maharashtra, India, [1]Department of Oral and Maxillofacial Surgery, Glasgow University Dental Hospital and School, Glasgow, Scotland, UK

Abstract

Introduction: Zygomatic implants are an effective solution for rehabilitation of edentulous atrophic maxillae. However, the conventional technique of zygomatic implant placement is invasive, requires a longer healing period and is economically cumbersome. Therefore, the flapless technique of insertion of zygomatic implants using dynamic navigation system has been introduced. This study aims to compare the cost-effectiveness of flapless insertion of zygomatic implants using dynamic navigation to the conventional flap technique. **Materials and Methods:** The study participants were divided into two groups: Group A ($n = 20$) included patients treated by flapless insertion of zygomatic implants using dynamic navigation and Group B ($n = 20$) included patients treated with zygomatic implants using the flap technique. An analysis of the effectiveness of the implants was done using the concept of quality-adjusted prosthesis years, and an analysis of the costs was done by evaluating the treatment costs at each step. The data were collected, and analysis was done using IBM SPSS software. The Kruskal–Wallis rank-sum test was employed to analyse variations in costs and effects between the two groups. **Results:** The study showed that the distribution of costs varies across both the categories of the procedure. Group B shows lesser cost-effectiveness as compared to Group A. **Conclusion:** The technique of flapless insertion of zygomatic implants is cost-effective. However, further studies considering factors such as time and cost of productivity evaluating the cost-effectiveness should be conducted.

Keywords: Atrophic maxilla, cost-effectiveness analysis, dynamic navigation, flapless technique, zygomatic implants

Introduction

Missing teeth can be a significant challenge for patients, leading to a lack of self-esteem, difficulty in speaking and eating and overall lower quality of life.[1] Dental implants are an answer to this problem to a great extent. However, in an atrophied edentulous maxilla, placement of a conventional implant is met with difficulty.[2] Zygomatic implants have emerged as an effective solution for these cases, providing a stable and long-term replacement for missing teeth.

Zygomatic implants are a type of dental implants that are used to replace missing maxillary teeth when the maxilla is severely atrophied. They were introduced by Branemark for posterior maxillary anchorage as well as to expedite the process of rehabilitation.[3] They are longer and wider than traditional dental implants and are anchored in the zygomatic bone. However, the surgical technique used to place these implants can greatly affect the outcome and cost-effectiveness of the treatment. The traditional flap technique for zygomatic implant insertion involves making a flap incision in the periodontium, raising the flap and then drilling a hole in the zygomatic bone for the implant.[3,4] This technique is invasive and can cause significant trauma to the soft tissue and bone. In addition, the traditional flap technique has numerous drawbacks such as perforation and infection of the maxillary sinus, delayed post-surgical healing and injury to the ocular

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Address for correspondence: Dr. Ashwini Bhalerao, Department of Oral and Maxillofacial Surgery, Saveetha Dental College and Hospital, Poonamallee High Rd, Velappanchavadi, Chennai, Tamil Nadu 600077, India. E-mail: drvaibhav1989@gmail.com

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nervous structures.[5] It requires a longer healing period and can result in further complications.

The flapless insertion of zygomatic implants is a minor surgical technique that involves placing the implants without the need for a flap incision.[6] It involves making a small incision in the gingiva, using a guide to direct the implant into the zygomatic bone and then securing the implant in place, throughout being guided by computer-assisted technology using a software to navigate the direction and angulation of implant placement.[7] This technique has been shown to be less invasive and less traumatic than the traditional flap technique and has the potential to be more cost-effective. A cost-effectiveness analysis is an important tool for systematically combining information about effective interventions with information about their costs. It highlights interventions that have the potential to reduce the burden of disease substantially.[8]

Therefore, this study aims to determine the cost-effectiveness of zygomatic implants using dynamic navigation. By doing so, it elaborates on the advantages, duration and complications as well as compares the financial cost with the health cost of both the techniques.

Materials and Methods

The present study followed a retrospective study design wherein the patients treated with zygomatic implants during the time period of October 2021–February 2023 were included. The approval for this study was obtained from the Institutional Review Board (IHEC/SDC/PhD/OMFS-1611/21/244).

Inclusion criteria

- Patients treated with zygomatic implants using dynamic navigation and followed up for a period of one year
- Patients treated with zygomatic implants using the flap or flapless technique and followed up for a period of one year.

Exclusion criteria

- Patients treated with any other kind of prosthesis
- Patients with a follow-up period of less than one year
- Patients with inaccessible or poorly documented data.

Within the review period, 74 patients were screened, and their data was subsequently evaluated, out of which, 18 were excluded due to a short review period and 16 were excluded due to inadequate documentation of the data. The selected sample was divided into two groups. Group A (n = 20) included patients treated by flapless insertion of zygomatic implants using dynamic navigation and Group B (n = 20) included patients treated with zygomatic implants using the flap technique. Demographic details and additional data regarding post-surgical complications and their subsequent management were also recorded.

The patients were evaluated at baseline and at three months postoperatively to assess several functional and psychological parameters related to their prosthesis. The assessment involved perceived chewing ability measured on the Visual Analogue Scale from 0 (worst possible outcome) to 10 (best possible outcome). The concept of quality-adjusted prosthesis years (QAPYs)[9] was used to determine the effectiveness of the intervention. QAPY is a concept derived from quality-adjusted life year, with values ranging from 0 (absent tooth) to 1 (prosthesis in perfect condition after one year). The QAPYs were calculated by considering the patient's degree of satisfaction according to function and aesthetics at three intervals: baseline, six months and one year after surgery.

The costs of the treatment included the basic tariff for radiographic investigations, diagnosis and treatment planning, implant material, surgical, prosthodontic and laboratory cost as well as operation theatre charges, drug costs and general anaesthesia costs. The cost of management of complications and maintenance charges post-surgery were also included in the study. This calculation was based on the average fee structure followed for each procedural step followed in India. All costs were recorded in Indian rupee (symbol: ₹; code: INR) for the year 2022.

Cost-effectiveness is expressed as a ratio of the difference in costs (i.e., incremental costs) divided by the difference in effects (i.e., incremental effects) between the two strategies, i.e., in patients treated with zygomatic implants using dynamic navigation with flapless technique and flap technique.

The Kruskal–Wallis rank-sum test was employed to analyse variations in costs and effects between the two groups. $P < 0.05$ was considered statistically significant. The bivariate distributions of mean total costs and QAPYs for both the treatment strategies were done and summarised in terms of two-way cost-effectiveness acceptability curves. For all statistical analyses, the Statistical Package for the Social Sciences (SPSS) (SPSS Inc., version 22, IBM, Chicago, Illinois, USA) software[10] was used.

Results

All the patients included in the study were in the age group of 40–60 years, with a mean age of 52.37 ± 3.42 years in Group A and 54.11 ± 2.12 years in Group B. In Group A, 65% of patients were male and 35% were female, whereas, in Group B, 55% were male and 45% were female. The imaging and diagnostic cost was ₹2524.90 (154.08) in Group A, whereas in Group B, it was ₹2530.25 (148.85). The material cost of implants for Group A was ₹94,620 ± 2813.61 and for Group B was ₹95,685 ± 2687.843. No statistical difference was seen in the diagnostic and material costs of both the groups ($P > 0.05$).

In Group A, no extra costs were needed for operation theatre, hospital management, general anaesthesia and drugs. These costs were required for Group B. Therefore, a significant difference was observed in the total operative costs of both the groups with a mean of ₹97,144.90 ± 2865.14 for Group A but ₹148,882 ± 2964.99 for Group B. This was statistically significant with $P < 0.05$. The total post-operative cost (complication management cost + maintenance cost) was ₹2810.30 ± 271.09 in Group A but ₹17,613.35 ± 2150.52 in Group B. This was statistically significant with $P < 0.05$. The total cost of procedure for Group A was

Table 1: The difference in average costs between Group A and Group B

	Mean	*N*	SD	SEM	Significance	
					One-sided *P*	Two-sided *P*
Diagnosis						
Group A	2524.90	20	154.078	34.453	0.394	0.788
Group B	2530.25	20	148.851	33.284		
Material costs						
Group A	94,620.00	20	2813.614	629.143	0.472	0.943
Group B	94,685.00	20	2687.843	601.020		
OT charges						
Group A	0.00	20	0.000	0.000	<0.001	<0.001
Group B	15,986.00	20	502.985	112.471		
Other hospital charges						
Group A	0.00	20	0.000	0.000	<0.001	<0.001
Group B	20,440.00	20	920.755	205.887		
GA charges						
Group A	0.00	20	0.000	0.000	<0.001	<0.001
Group B	12,540.50	20	275.251	61.548		
Drugs						
Group A	0.00	20	0.000	0.000	<0.001	<0.001
Group B	5230.50	20	150.559	33.666		
Total operative cost						
Group A	97,144.90	20	2865.140	640.665	<0.001	<0.001
Group B	148,882.0	20	2964.990	662.992		
Complication management cost						
Group A	1945.30	20	214.791	48.029	0.005	0.010
Group B	15,863.35	20	21,545.688	4817.762		
Maintenance cost						
Group A	865.00	20	143.435	32.073	0.107	0.214
Group B	885.00	20	143.435	32.073		
Total post-operative cost						
Group A	2810.30	20	271.098	60.619	0.003	0.006
Group B	17,613.35	20	2150.515	4807.661		
Total costs						
Group A	99,955.20	20	21,484.893	4804.168	<0.001	<0.001
Group B	166,495.35	20	22,761.836	5089.701		

OT: Operation theatre, GA: General anaesthesia, SD: Standard deviation, SEM: Standard error mean

₹99,955.20 ± 21,484.89 and ₹166,495.35 ± 22,761.84 in Group B. This was statistically highly significant with $P < 0.001$, as depicted in Table 1.

The QAPYs were calculated at baseline, six months and one year after the procedure. At baseline, the mean QAPY in Group A was 0.557, whereas in Group B, it was 0.516. At six months after procedure, the mean QAPY was 0.792 for Group A and 0.763 for Group B. At one year after the procedure, the mean QAPY was 0.856 for Group A and 0.864 for Group B.

The *P* value determined was <0.05 at baseline and six months. This was statistically significant. However, one year after the procedure, no significant difference was seen in the QAPYs of both the groups, as depicted in Table 2.

The average cost-effectiveness ratio is depicted in Table 3. The stochastic two-way analysis showed that the technique of flapless insertion of zygomatic implants is more cost-effective at ₹116,770.09/year as compared to the flap technique at ₹192,702.95/year.

Table 2: The average mean values of quality-adjusted prosthesis years for Group A and Group B

	Mean	*n*	SD	SEM	*P*
Baseline					
Group A	0.557	20	0.028	0.00620	<0.001
Group B	0.516	20	0.047	0.01057	
6 months					
Group A	0.792	20	0.053	0.01188	0.030
Group B	0.763	20	0.031	0.00703	
1 year					
Group A	0.856	20	0.036	0.00816	0.207
Group B	0.864	20	0.030	0.00682	

SD: Standard deviation, SEM: Standard error mean

Table 3: The cost-effectiveness for Group A and Group B

	Cost	Effect	Cost-effectiveness
Group A (flapless)	99,955.2 (2839.261)	0.856 (0.03)	116,770.09
Group B (flap)	166,495.35 (22,761.836)	0.864 (0.03)	192,702.95

Table 4: The Kruskal–Wallis hypothesis test

Null hypothesis	Test	Test statistic	Significant[a,b]	Decision
The distribution of cost-effectiveness is the same across Group A and Group B	Independent samples Kruskal–Wallis test	28.5	<0.001	Reject the null hypothesis

[a]The significance level is 0.050, [b]Asymptotic significance is displayed

The Kruskal–Wallis test [Table 4] showed that the distribution of costs is not the same across both the categories of the procedure. Group B shows lesser cost-effectiveness as compared to Group A, as depicted in Table 3 and Figure 1.

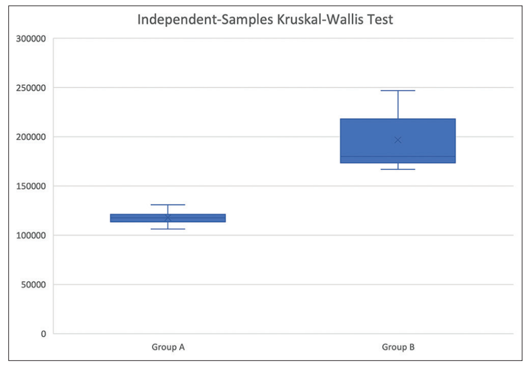

Figure 1: The boxplots of costs and quality-adjusted prosthesis year outcomes

Discussion

Placement of implants involves high costs and investments as compared to other oral rehabilitation modalities such as complete dentures and implant-supported dentures. The cost of investment is further higher in the flapless placement of zygomatic implants using dynamic navigation as compared to the conventional technique. However, this study showed that in spite of the greater cost at baseline, the technique of flapless insertion using dynamic navigation is cost-effective over the years in terms of QAPYs.

This study demonstrated that in Group A (flapless technique), the computer-aided dynamic navigation system gives relatively fast and accurate results as compared to Group B (flap technique). The operating time is significantly reduced and is nearly free of any morbidity or post-operative complications. The number of recalls and follow-up periods of the patient is also reduced. The patient is comfortable as no flap is raised and is ready to resume normal life in a short time of recovery. Overall, it was found that the patients in Group A saved time, adding to the total cost-effectiveness of the procedure.

Whereas, in Group B (flap technique), additional costs were incurred for the customisation of surgical template guides, general anaesthesia and operation theatre. Raising of the flap causes increased operative time, delays wound healing and causes post-operative pain and discomfort to the patient. The number of recalls is higher and the follow-up period is longer. This is challenging, not only physically but also mentally and emotionally. This is relevant to the scope of this study, as it affects the functionality and performance of the patient upon return to daily life, especially in terms of productivity and thereby affecting the ‘costs’ of this procedure.

The results of our study are in agreement with a similar study conducted by Ravidà *et al*.,[11] which concluded that computer-guided implant placement shows higher rates of survival and comparably lesser long-term cost as compared to non-guided implant placement. In a study conducted by Gebretsadik,[12] effectiveness of up to 94% was derived through analysis of a cumulative success rate in zygomatic implants placed through the conventional technique. Whereas, Wu *et al*.,[13] in their study, determined that the zygomatic implants placed through dynamic navigation showed an effectiveness rate of 98.64%.

An increased radiation exposure to the patient is an important drawback of implant surgeries, especially in those assisted by dynamic navigation as demonstrated by Kunzendorf *et al*.[14] However, the technique demonstrated in this study has an equal amount of radiation exposure to the patient in both the conventional technique and the flapless technique assisted by dynamic navigation. A pre-operative cone-beam computed tomography (CBCT) is taken to pre-plan the site and the position of the placement of the zygomatic implants, and the post-operative scanning is used to assess the accuracy of the achieved results. In dynamic navigation, the pre-operative CBCT is used to guide the placement of the zygomatic implant during surgery. This is achieved using the stereo-pair of cameras of the dynamic navigation system without exposing the patient to any harmful radiation during surgery. Hence, needless exposure of the patient to radiation is prevented.

The technique of flapless insertion of zygomatic implants requires intensive training, and a learning curve has to be taken into consideration while training students and young professionals. In a study conducted by Spille *et al*.,[15] the accuracy of implant placement by young professionals was evaluated using dynamic navigation. It yielded a statistical significance in the accuracy of angle as well as position of the implants to the apex as compared to the entry point and angular deviations. Furthermore, there was a subjective improvement in handling the dynamic surgery system by these professionals. The study concluded that the technique of using dynamic navigation for implant placement requires the operator to be highly skilled. However, it can be learnt quickly and incorporated into daily clinical practice.

In a systematic review conducted by Ramezanzade *et al*.,[16] the technique of Dynamic-Assisted Navigational System in Zygomatic Implant Surgery was evaluated on the basis of accuracy and complications. The study yielded that the reliability and accuracy of dynamic navigation techniques in large randomised and prospective controlled studies do not meet the threshold of acceptability.

Therefore, it is suggested that further research in the form of randomised and prospective clinical studies be conducted to understand the gap in the literature in relation to the cost-effectiveness of zygomatic implants using both the conventional technique and the dynamic navigation technique.

Conclusion

The present study showed that the technique of flapless insertion of zygomatic implants is more cost-effective as compared to the conventional flap technique. Flapless insertion is a quick and accurate technique, with minimal post-operative complications. By having less operative time, the number of recalls and follow-up periods, it is not only cost-effective in terms of the costs incurred but also the time saved.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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