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RESEARCH ARTICLE

Prescription of antibiotics in bone augmentation with dental implant

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Aim: To evaluate the success and failure in bone augmentation with dental implant cases when antibiotics were used with different timing in long follow-up periods.

Material and Method: 120 patients were randomly put into three groups: (1) no antibiotic treatment (NOAB); (2) preoperative and postoperative antibiotic treatment (PPAB) with 1.5 g of amoxicillin an hour before surgery and 500 mg three times a day for five days after surgery; and (3) postoperative antibiotic coverage (POAB) with 500 mg three times a day starting after surgery and continuing for five days after surgery. We conducted a comparison and follow-up of patients to detect antibiotic responses in the context of bone augmentation and dental implants.

Results: We recorded highly significant differences in age groups and gender. We observed highly significant differences (0.000, 0.000, and 0.041) on the third day, the 12th week, and after six months of follow-up. The results indicated that in group 1, 7 implants (11.6%) failed, while in group 3, only 2 implants (3.33%) failed. In contrast, in group two, all implants succeeded (100%).

Conclusion: The use of preventive antibiotics resulted in a very low infection rate. Conversely, the absence of preventive antibiotics significantly increased the infection rate. A higher number of studies were required to analyze the biological factors that contributed to failure in the case of various antibiotic doses and types.

Keywords: antibiotic prophylaxis, bone transplantation, dental implants, post-surgical antibiotics, retrospective study

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Introduction

The prescription of antibiotics in bone augmentation procedures with dental implants is an essential strategy for preventing postoperative infections, which can undermine the success of the surgery and implant integration.

Dental implants are a widely used solution for replacing missing teeth, but in cases where there is insufficient bone volume or density, bone augmentation techniques such as bone grafting, sinus lifts, and guided bone regeneration are often required [1]. These procedures, due to their invasive nature and the introduction of biomaterials into the body, increase the risk of infection, which can compromise healing and lead to implant failure [2].

To minimize the risk of infection, both prophylactic (pre-operative) and therapeutic (post-operative) antibiotics are commonly prescribed. Prophylactic antibiotics are typically administered shortly before surgery to reduce the bacterial load in the surgical area, while post-operative antibiotics help prevent infections during the healing phase [3].

The use of antibiotics in this context is particularly critical in high-risk patients, such as those who are immune-compromised or suffer from systemic conditions like diabetes or cardiovascular disease [4]. However, the use of antibiotics must be balanced carefully to avoid overuse and the development of antibiotic resistance, a growing concern in clinical settings [5].

Antibiotic stewardship strategies, which emphasize appropriate dosing, duration, and selection of antibiotics, are important to ensure the efficacy of treatment and patient safety [6].

Since bone augmentation is a common procedure in dentoalveolar surgery, the use of antibiotics for this reason in otherwise healthy patients may make a big difference in the total amount of antibiotics used in general dentistry. Therefore, any effort to limit wasteful consumption is of the utmost importance. This is because the development of antibiotic resistance is considered the greatest threat to current health care [7]. This paper aims to explore the rationale behind antibiotic use in bone augmentation with dental implants, reviewing current practices and considerations for individual patients. This is considered the first clinical study performed in Nineveh Province, Iraq.

Aim of the study

To evaluate the success and failure in bone augmentation with dental implant cases when antibiotics used.

Objectives of the study

Explore the rationale behind antibiotics used in bone augmentation cases. Additionally, a time comparison between the success and failure of the cases will be discussed. The effect of long follow-up periods will be highlighted.

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Patients and Method

The Nineveh Health Directorate/Ministry of Health, Iraq, approved the research application form based on the scientific committee's recommendation. The Human Ethical Scientific Approval License number is (250) 2023 in 6 / 12 / 2023. A thorough explanation and discussion of all procedures were received by the participants. Written informed consent with regard to treatment and measurement procedures was given by all patients, and approval from the Research Committee in our directorate was obtained.

Oral rehabilitation by dental implants was required for 120 consecutive medically fit patients with varying patterns of tooth loss, ranging from single to multiple teeth replacement (not more than 6 teeth). All the implants originated from one manufacturer (Superline, Dentium, Korea) with the bone substitute material (Osteon III). All patients were operated on by the same oral/maxillofacial surgeon in 2 different places (a special private clinic and a dental implant unit in the maxillofacial department of the Al-Salam Teaching Hospital) in the period from 1/1/2018 to 1/12/2021. Both males and females are involved in this study.

Including criteria: Patients included in this study were as follows:

- Aged from 18-50 years old.
- Medically healthy candidate.
- No history of drug allergy or drug abuse.
- Agree to share in the study and agree to be followed for 3 years.
- Moderate to Sever dental implants procedures which need bone substitutes.

Patients were excluded from the study if any of the following criteria were present:

- History of antibiotic therapy 6 months prior to the study.
- Allergic patients to penicillin or other drugs.
- Pregnant ladies.
- Patients not like to share.
- Unwillingness to return for the follow-up examinations.
- Advanced implant surgeries as maxillary sinus lifting and inferior alveolar nerve translocation.

The patients were divided into 3 groups, each involving 40 participants, with 60 dental implants being placed in different sites as follows:

- Group A: 40 patients, 60 dental implants, with no antibiotic treatment prescribed (NOAB).
- Group B: 40 patients, 60 dental implants, with preoperative and postoperative antibiotic treatment (PPAB), consisting of amoxicillin 1.5 g 1 hour before surgery and 500 mg three times per day/ for 5 days following surgery.
- Group C: 40 patients, 60 dental implants, postoperative antibiotic coverage (POAB) consisting of and 500 mg three times per day, started after surgery and continued for 5 days after surgery.

Patients Selection

The patients initially presented with various edentulous sites in the upper and lower arches, either unilaterally or bilaterally. These edentulous sites included the loss of a single tooth or several teeth, but the total number of implants did not surpass six. At this time, comprehensive clinical and radiological evaluations, along with diagnostic cast preparations, were undergone by every candidate prior to the surgical procedures. Thorough mouth scaling was received by the patients before the operation to maintain an oral environment that was more conducive to the healing of wounds. Before the operation, patients were instructed to rinse their mouths with a 0.2% chlorhexidine gluconate solution for one minute. This step was performed before each procedure. When bone augmentation was performed, the corresponding guidelines for delayed implant placement were followed. Following the standard two-step surgical technique for implant placement, a three-month waiting period was observed for the healing process to occur in both the soft and rigid tissues, after which either a single or multiple fixed prostheses were fabricated.

We recommended that the patients use ice packs and non-steroidal anti-inflammatory drugs (paracetamol tablets, 500 mg twice daily for one day) following the surgical procedure.

It was also recommended to the patients to maintain good oral hygiene by rinsing their mouths with chlorhexidine gluconate 0.2% twice daily for a period of fifteen days after surgery and that to refrain from brushing the area that has been surgically treated for a period of two weeks. Post-surgical examinations were performed three days, one week, four weeks, respectively twelve weeks following surgery, to assess the healing process of the soft tissues and to look for any signs that may have indicated the existence of infections. These signs included edema, erythema, discomfort, heat, and exudate. In addition, radiographic examinations for bone healing assessment were carried out after the insertion of the prosthesis at the following times: six months, one year, two years, and three years. Implant failure was characterized as the loss of bone integration of the implant, which is the biological cause of implant failure.

Statistical analysis was conducted using the commercial package SPSS. Chi Square Test for the difference of group means was applied. A P value of ≤0.05 demonstrated the effectiveness of the different approaches.

Results

Age was distributed into four ranges (21–25 years, 26–30 years, 31–35 years, and 36–40 years) within each group. A comparison between the groups revealed statistically significant differences (P = 0.024) using the Chi-square test (Table 1).

Table 2 show a gender descriptive analysis for the three groups. Significant differences were found between the groups (p-value ≤ 0.05).

Table 1. Descriptive analysis of age distribution

Group	Age (Years)	Total No.	%	P-Value
No Antibiotic Use (Total No. 40pt)	21 - 25 Years	8	20	
	26 - 30 Years	15	37.5	
	31 - 35 Years	14	35	
	36 - 40 Years	3	7.5	
Antibiotic Use (Pre and Post-Operative) (Total No. 40pt)	21 - 25 Years	8	20	
	26 - 30 Years	13	32.5	0.024* $\chi 2 = 31.638$
	31 - 35 Years	10	25	
	36 - 40 Years	9	22.5	
Antibiotic Use Post-operative only (Total No. 40pt)	21 - 25 Years	12	30	
	26 - 30 Years	14	35	
	31 - 35 Years	13	32.5	
	36 - 40 Years	1	2.5	

* Significant at p-value ≤ 0.05, by using Chi-Square test

Table 2. Descriptive Analysis of Gender Distribution

Group	Gender	No. of Patients	%	P-Value
No Antibiotic Use (Total No. 40pt)	Male	18	45%	
	Female	22	55%	
Antibiotic Use (Pre and Post-Operative) (Total No. 40pt)	Male	19	47.5%	0.018* $\chi 2 = 5.633$
	Female	21	52.5%	
Antibiotic Use Post-operative only (Total No. 40pt)	Male	10	25%	
	Female	30	75%	

* Significant at p-value ≤ 0.05, by using Chi-Square test.

The number of implants varied across individuals, ranging from a single implant per patient, up to six implants in others. Highly significant differences were found at p-value ≤ 0.01, by using Chi-Square test (Table 3).

Data regarding the follow up period and failures of implants in different groups is presented in Table 4 and Figure 1. Starting the third day, follow up clinical symptom and signs (pain, dehiscence, edema and exudate) were gathered. In the third day, 12th week and after six months , the follow-up data showed significant differences (0.000, 0.000 and 0.041).

Failure was observed in groups 1 and 3: from group one, 7 implants (11.6%) failed, while in group three, only 2 implants (3.33%) failed. In contrast, all implants in group two were successful (100%), as clearly seen in Table 5.

Discussion

This study shows that most of the patients who under¬went bone augmentation procedures prior to dental implant treatment received different antibiotic prescriptions divided into 3 groups (with no antibiotic use, with pre- and post-surgery antibiotic use, and with post-surgery antibiotic use).

The analysis highlights several important findings regarding age, gender, implant number distributions, and outcomes in different groups receiving varied antibiotic regimens during dental implant procedures.

Studies conducted in the past have reached the conclusion that dental practitioners who did not always adhere to clinical recommendations were not aware of the most recent clinical guidelines for antibiotic prophylaxis, although these guidelines were available [8]. Furthermore, a lack of

Table 3. Implant Number's Distribution on Patients

Group	No. of Implant	No.	%	P-Value
No Antibiotic Use (Total No. 40pt)	Single Implant	24	60.0	
	Two Implants	12	30.0	
	Three Implants	4	10.0	
	Total	40	100.0	
Antibiotic Use (Pre and Post-Operative) (Total No. 40pt)	Single Implant	19	47.5	
	Two Implants	13	32.5	<0.01** Chi-Square test = 82.467
	Three Implants	7	17.5	
	Four Implants	1	2.5	
	Total	40	100.0	
Antibiotic Use Post-operative only (Total No. 40pt)	Single Implant	23	57.5	
	Two Implants	14	35.0	
	Three Implants	3	7.5	
	Total	40	100.0	

** Highly Significant at p-value ≤ 0.01, by using Chi-Square test

Table 4. Follow up Periods Concerning Complications and P Value Comparison

Follow-up Periods	P-values	Test	
After 3 Days	0.000**	Chi-Square test = 317.667	**Highly Significant at p-value ≤ 0.01
After 1st Week	1.000+		No significant differences
After 4th Week	1.000+		No significant differences
After 12th Week	0.000**	Chi-Square test = 53.333	**Highly Significant at p-value ≤ 0.01
After 6th Months	0.041*	Chi-Square test = 2.970	* Significant at p-value ≤ 0.05,
After 1st Year	1.000+		No significant differences
After 2nd Year	0.200+	Chi-Square test = 0.655	No significant differences
After 3rd Year	0.200+	Chi-Square test = 0.655	No significant differences

*Highly Significant at p-value ≤ 0.01(After 3 days, After 12 weeks, and after six months)

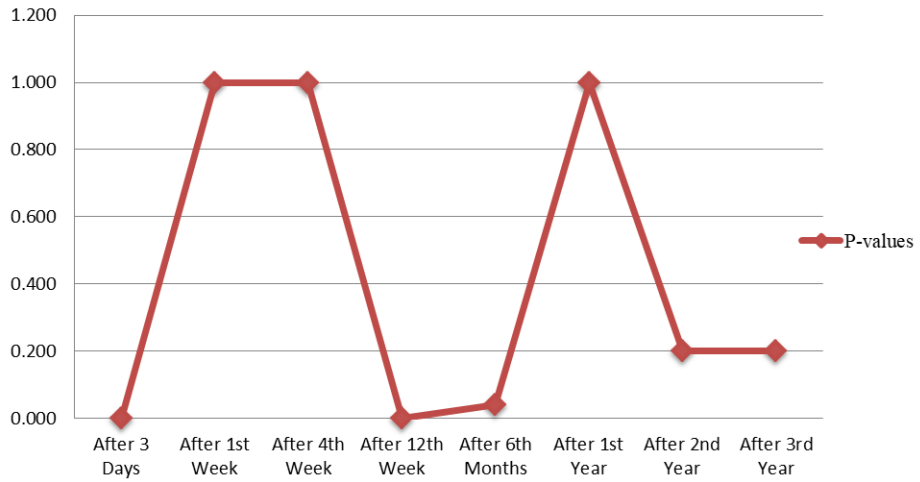

Fig. 1. Follow up Periods Concerning Complications and P Value Comparison

Table 5. Success versus Failure of dental Implant Comparison between the groups

Group		No.	%	P-Value
No Antibiotic Use (Total No. 40pt)	Success	53	88.33	
	Failure	7	11.6	
	Total	60	100.0	
Antibiotic Use (Pre and Post-Operative) (Total No. 40pt)	Success	60	100.0	0.041* Chi-Square test = 2.970
	Failure	0	0	
Antibiotic Use Post-operative only (Total No. 40pt)	Success	58	96.7	
	Failure	2	3.33	
	Total	60	100.0	

* Significant at p-value ≤ 0.05, by using Chi-Square test.

information regarding the scientific evidence concerning the proper and efficient prescription of antibiotics may contribute to a reduction in the incentive to align with the recommendations of consensus.

More than 11% of the patients in the current study developed postoperative infections. Compared to the group receiving antibiotics, the patients without antibiotics experienced significantly more infections. One possible explanation for these findings is that the type of surgery that was conducted, which was a clean-contaminated procedure, had a risk of infection that ranged from 10–15%. However, the use of appropriate surgical techniques and the administration of prophylactic antibiotics can reduce this risk by 1% [9]. We must exercise caution when interpreting these findings, as the primary purpose of the current study was not to address postoperative infections. In contrast, infections after these treatments are low, regardless of antibiotic regimen.

Nearly half of the patients underwent the dental implant installation and bone augmentation procedures simultaneously. In the remaining patients, we placed the implant after the bone augmentation had healed. Von Arx and Buser have proven that the volume of bone at the host site determines the optimal time for implant placement, which can either occur simultaneously with the graft insertion or after the installation of the bone block [10]. If the residual bone is able to accommodate the correct placing of the implant while maintaining primary stability, then it is appropriate to do simultaneous implant placement with the bone transplant procedures [11]. On the other hand, some researchers found that delaying the implant placement would improve the bone graft's revascularization, which could lead to better bone-implant contact and secondary stability [12]. As a result, it is necessary to customize the optimal timing for implant and prosthesis installation in accordance with the various bone grafts.

The current study can be considered the first step in a drug utilization evaluation that evaluates antibiotic prescribing for patients who have undergone bone augmentation procedures in conjunction with dental implant

therapy in Iraq. One of the limitations of the current study is that it adopts a retrospective design. On the other hand, the clinical validity of retrospective studies based on routine patient care (effectiveness studies) and the more trustworthy and scientifically sound RCT study design are limited [13]. On the other hand, a retrospective approach has the potential to eliminate the blinding impact on prescribing behavior. The surgeons' inherent blindness to the researchers' research topic accounts for this.

Age Distribution: The age groups (21–25, 26–30, 31–35, and 36–40 years) showed significant differences in distribution among the three treatment groups (p=0.024). Such differences may suggest age-related preferences or suitability for specific antibiotic regimens [14].

Gender Distribution: We observed significant gender differences (p=0.018). Female patients dominated the "post-operative only" group (75%), while the other two groups had more balanced gender distributions. The reasons for these variations could include biological differences or treatment preferences among genders. Age and gender as factors influencing implant success or complications remain inconsistent across literature. Studies indicate that younger age groups may heal faster, and females may have better soft-tissue response but also show higher levels of implant-related anxiety [15, 16].

Implant Number Distribution: The number of implants per patient ranged from one to six. Highly significant differences were found across groups (p≤0.01). This evidence suggests that comprehensive antibiotic use might be associated with more extensive implant procedures. Studies showed that more implants relate to more complicated surgery, which may benefit more from antibiotic pretreatment [17], supporting the link between the number of implants and failure rates.

Follow-up Periods and Complications. Post-operative complications were assessed at multiple follow-up points. Significant differences were noted at critical early intervals:

3 Days: High significance (p=0.000), likely reflecting early responses to the antibiotic regimens.

12th Week: Continued significant differences (p=0.000), indicating prolonged effects of treatment protocols.

6 Months: Moderate significance (p=0.041), suggesting a diminishing, yet persistent impact.

Long-term follow-ups (1–3 years) did not show significant differences, indicating that initial treatment strategies might primarily influence early outcomes. Early follow-up intervals (3 days and 12 weeks) showed significant differences in complications across groups, with better outcomes linked to antibiotic use. Long-term follow-ups (1–3 years) showed no significant differences. Studies such as those by Renvert and Quirynen [17] report that antibiotics help minimize early complications like infection, pain, and swelling. However, they highlight that surgical technique and patient compliance play a more significant role in long-term outcomes [18].

Success and Failure Rates

Implant success varied significantly among groups:

- The "Pre and Post-operative Antibiotic Use" group achieved a 100% success rate, highlighting the effectiveness of this regimen in preventing failures.
- The "Post-operative Only" group had a high success rate (96.7%) with minimal failures (3.33%).
- The "No Antibiotic Use" group recorded the lowest success rate (88.33%) and the highest failure rate (11.6%).

These findings emphasize the protective role of antibiotics, especially in both pre- and post-operative phases, in ensuring successful implant outcomes.

A 100% success rate in the pre- and post-operative antibiotic group highlights the effectiveness of comprehensive antibiotic regimens. The success rates decline with no antibiotic use (88.33%) or post-operative-only protocols (96.7%).

Numerous studies have shown that pre- and post-operative antibiotics reduce implant failure rates significantly. However, there is debate regarding the necessity of antibiotics in straightforward, non-complex cases. Some studies argue against routine prophylactic antibiotic use due to resistance risks, suggesting we should reserve antibiotics for high-risk patients or complex cases. Additionally, the "No Antibiotic Use" group experienced the highest number of failures (11.6%), while the "Post-operative Only" group experienced fewer failures (3.33%), and the "Pre and Post-operative" group experienced no failures at all.

Studies like those by Chrcanovic et al. (2016) and Khouly et al. (2020) [18, 19] affirm that implant failure rates are lower with antibiotic prophylaxis. However, others also emphasize the multifactorial nature of failures, including host factors (smoking, diabetes), surgical expertise, and implant design [20, 21].

Clinical Implications

- The study underscores the importance of tailoring antibiotic regimens based on patient-specific factors such as age, gender, and procedure complexity.
- The significant differences in implant success rates suggest that adopting a combined pre- and post-operative antibiotic strategy could optimize outcomes.
- While early follow-up periods show critical variations in complications, long-term stability appears less influenced by the choice of regimen, suggesting initial care is crucial for success.

Conclusion

The amount of scientific evidence that supports the use of antibiotic prophylaxis to reduce the risk of infection during bone augmentation procedures and subsequent dental implant insertion is quite minimal. We have demonstrated that the use of preventive antibiotics results in a very low infection rate. Conversely, the absence of preventive antibiotics significantly increased the infection rate. A greater

number of studies are required to analyze the biological factors that contribute to failure in the case of various antibiotic doses and kinds.

Authors Contribution

OWS: Conceptualization, Data curation, Formal Analysis, Funding acquisition
BAT: Resources, Software, Supervision, Validation
RYA: Writing – original draft, Writing – review & editing, Investigation, Methodology, Project administration

Conflict of interest

None to declare.

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