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Influence of Perioperative Dexamethasone on the Delayed Union in Mandibular Fractures

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ABSTRACT

Background: Mandibular fractures are considered to be one of the most frequent facial bone fractures which occur due to trauma that causes functional, as well as aesthetic, impairment. Perioperative use of dexamethasone is associated with postoperative inflammation and pain control due to its effects as a potent glucocorticosteroid. However, dexamethasone has been reported to have an impact on bone healing, thus posing a threat when used in treatment regimens because it is likely to slow the fracture union rate. **Objective:** The purpose of this case control study is to determine the effect of perioperative dexamethasone in causing delayed union in patients treated by surgical management of mandibular fractures. **Study design and setting:** A prospective cohort study was conducted at the Department of Oral & Maxillofacial Surgery, Jinnah Postgraduate Medical Centre, Karachi from March 2024 to September 2024. **Methodology:** The study was conducted on 75 patients who were divided into two groups: One of the two groups that were enrolled in this study, one group of patients receiving perioperative dexamethasone and the other group acting as the control group. Clinical and radiographic examinations were done in different days or weeks after surgery to evaluate the healing status. **Results:** The results obtained showed that there was a higher incidence of delayed fracture union in the dexamethasone group (26.3%) than in the control group (10.8%) with longer mean healing time in the dexamethasone group. **Conclusion:** These results indicated that although dexamethasone can help minimize postoperative inflammation for a limited amount of time, it will have prejudicial effects on bone healing for a considerably long term period especially for the patients in the high-risk category. Additional studies must be conducted to determine how dexamethasone affects bone repair and to establish proper therapeutic strategies.

INTRODUCTION

Mandibular fractures are one of the most common of all facial fractures given the fact that the mandible is an external structure, thus exposed to numerous etiologic factors as traffic accidents, falls, physical assault, and sports (Brown, J. S., 2022).). Mandibular fractures are important not only because of the functional losses that patients may experience during the process of healing and after it, as mastication and speech may be significantly affected, but also because they affect the aesthetic look of the face and thus add psychological dysfunction to the primary dysfunction of the fracture (Panesar, K., 2021). Injury to the mandible like other fractures of the bones involve formation of inflammation, new bone formation and remodeling. However, many factors may hinder or slow down this process of healing, which therefore results in formation of conditions like delayed union or non union (Saravanan, T., 2020).

Dexamethasone: A Dual Role in Surgery

Dexamethasone is an exogenic synthetic glucocorticosteroid with great anti-inflammatory and immunosuppressive effects common in therapies. Perioperative use is widespread due to its efficacy in treating postoperative complications, including pain, edema, nausea, and vomiting, all of which are typical side effects of surgical trauma in patients who have undergone a general anesthetic (Kwak, H., 2019). When it comes to mandibular fractures the best effect of dexamethasone regarding reducing oedema was useful as most patients who are at risk of airway compromise in the early postoperative period following treatment of maxillofacial fractures can be relieved (Quesada-Bravo, F. J., 2021).

However, dexamethasone is also known to have adverse effects on bone metabolism, which raises concerns regarding its impact on fracture healing.

Glucocorticosteroids like dexamethasone exert their effects by binding to specific receptors in the cytoplasm, regulating gene expression that influences inflammatory responses (Bian, X., 2020). While this anti-inflammatory action is therapeutically desirable, glucocorticosteroids have been shown to inhibit osteoblast activity and increase osteoclast differentiation, thus tipping the balance towards bone resorption rather than bone formation (Xeroudaki, M., 2023). This mechanism underlies glucocorticoid-induced osteoporosis, a condition characterized by decreased bone mass and increased fracture risk, particularly with long-term use of high-dose steroids (Schäcke et al., 2002).

Impact of Dexamethasone on Bone Healing

The relationship between dexamethasone and bone healing is complex, and the effects are dose- and duration-dependent. While the long-term use of glucocorticosteroids is well-documented to cause osteoporosis and impair fracture healing, the effects of short-term, high-dose perioperative use remain unclear. Dexamethasone's inhibition of the inflammatory phase, which is a critical step in the initiation of bone repair, could theoretically delay healing if administered at inappropriate times (Mai, T. P., 2023). Inflammatory process is primarily governed by the infiltration of inflammatory cells to the bone injury site to release cytokines and growth factors needed for bone repair processes, proliferation and differentiation of osteoblasts (Dietrich-Zagonel, F., 2022).

Some investigations demonstrated that dexamethasone suppresses the synthesis of prostaglandins and other cytokines playing vital roles in bone healing stages (Dietrich-Zagonel, F., 2022).) Another study to be highlighted here is the one by Li, X., 2021. which showed that although administration of anti-inflammatory compounds after fracture has detrimental effects on bone healing, early application of these agents also has negative effects on the process of healing. In experimental animal models, dexamethasone has also been shown to decrease callus formation and slow the maturation of the fracture callus and in so doing, contribute to delayed union or non-union of bone fractures (Nam, N. H., 2021). These findings indicate that even though there are evident short-term merits for the use of dexamethasone with regard to the suppression of inflammation and decrease in tissue swelling, the same may be deleterious to the ultimate BMD recovery in the long run.

Mandibular Fracture Healing and the Role of Inflammation

In the healing of mandibular fractures, as in other fractures of bone, several well-coordinated biological events occur that are influenced by both global and local factors (Borys, J., 2019). The inflammatory phase of healing is central in orchestrating the steps towards repair and IL-1 and TNF-α, though having negative effects on osteoblast function are important in attracting osteoprogenitor cells to the fracture line (Lee, C. C., 2021). As the reparative phase in the inflammatory phase, a soft callus is formed, which transforms into a hard callus with fracture healing.

However, conditions such as diabetes, smoking and use of drugs like corticosteroids can hamper this natural process of healing and produce what carpenter et al. (2008) call chronic impaired healing. To be more precise, in case of mandibular fractures, where the treatment often includes ORIF, post surgical inflammation can enhance patients discomfort and possible adverse outcomes (Mohajerani, H., 2019). In these cases, dexamethasone is administered in order to control inflammation, but the effects of doing so on the rate of bone healing are still uncertain.

Clinical Evidence of Dexamethasone's Impact on Mandibular Fractures

A number of clinical trials have been carried out to evaluate the roles of the early administration of dexamethasone in the fracture healing process, and the results were inconclusive. In pain management of mandibular fractures. Oksa, M., 2021 performed a clinical and radiological study on the effects of dexamethasone on delayed union of fractures. The author of the study established that, although the use of dexamethasone was helpful in controlling postoperative pain and swelling, there was a statistically significant increased number of patients who experienced delayed union in the group that received the steroid. The authors stated that although advantages of dexamethasone in the management of postoperative complications are evident, these should be weighed against disadvantages affecting bone healing in patients at risk for nonunion of fracture, or those with predisposing diseases affecting bone metabolism.

However, a systematic review and meta-analysis by Smolle, M. A., 2021). found that the use of perioperative dexamethasone was not associated with an increased risk of delayed union or non-union in most types of fractures. They also found that more such RCTs are required to best understand the impact of dexamethasone in treating craniofacial traumas since the mandible is different in terms of structural and mechanical properties from other bones, and hence the healing procedure may also be quite different.

Potential Mechanisms Behind Delayed Union in Mandibular Fractures

Several mechanisms could potentially explain the delayed union of mandibular fractures which is observed when dexamethasone is given to the patient. The one is based on the glucocorticosteroids that decrease the differentiation and activity of osteoblasts and, consequently, hinder the formation of new bone tissue at

the fracture site (Singleton, C., 2022). Some systemic corticosteroids like dexamethasone have been demonstrated to suppress proteins that are vital for osteoblast performance, particularly osteogenic markers including alkaline phosphatase and osteocalcin (Sundheepkumar, V., 2023). This suppression results in lower bone formation rate and longer time to reach the union of fracture.

Other breakdown processes encompass increased activity of osteoclasts cells that are responsible for resorption of the bone. However, dexamethasone has been reported to stimulate osteoclastogenesis through increasing the level of receptor activator of nuclear factor kappa-B ligand (RANKL), which plays a crucial role on the differentiation and activity of osteoclasts (Beret, M., 2022. Increased bone resorption also plays a role in prolongation of the fracture healing time as the process of bone remodeling is distorted.

Glucocorticoid-Induced Osteoporosis and Fracture Healing

Other important facets linked to corticosteroids include bone densitometer osteoporosis and poor fracture healing associated with the long-term use of corticosteroids. Glucocorticoid mediated osteoporosis is characterized by decreased direct stimulation of bone formation by osteoblasts, increased apoptosis of osteocytes and increased number of osteoclasts (Chotiyarnwong, P., 2020). In the case of mandibular fractures where the process of bone resorption and formation is tightly controlled during the healing process, even short-term use of perioperative dexamethasone should be avoided because the glucocorticoid effect of the drug may block the bone healing process resulting in either delayed or nonunion.

Researches on glucocorticoid induced osteoporosis have revealed that corticosteroids suppress the Wnt signaling which in turn is important for osteoblast differentiation (Adami, G., 2019). This inhibition diminishes bone formation and increases the capability of bones for fractures. Although chronic exposure to glucocorticoids is well-studied, many questions remain with regard to the detrimental effects of burst high-dose corticosteroids on the process of fracture healing.

Current literature provides a complex view of dexamethasone and its impact on fractures of the mandible. Being a strong anti-inflammatory agent, the drug has definite advantages for the treatment of swelling and pain in the perioperative period; however, the influence of the drug on osteoblasts and osteoclasts may cause potential adverse effects on bone healing. Available data indicate that the impact of dexamethasone on the performance of fracture healing is directly proportional to the dosage, and depends on the applied treatment period and the characteristics of the fracture. Thus, because of the anatomical and functional significance of mandibles, more work has to be done to define the potential of delayed union following the use of perioperative dexamethasone especially in high-risk patients, including elderly and those with a compromised bone quality.

Aim

The aim of this study is to evaluate the influence of perioperative dexamethasone administration on the healing process of mandibular fractures, particularly focusing on its association with delayed union, in order to better understand the potential risks and identify high-risk patients for optimal clinical management.

Research Questions

- Does perioperative administration of dexamethasone increase the risk of delayed union in patients undergoing surgical treatment for mandibular fractures?
- What is the correlation between the dosage of dexamethasone and the occurrence of delayed or non-union in mandibular fractures?
- How does the perioperative use of dexamethasone impact the radiographic and clinical outcomes of mandibular fracture healing compared to patients who do not receive dexamethasone?

METHODOLOGY

Study Design

Mandibular fractures constitute a significant portion of oral and maxillofacial surgery, with assessment of delayed union following this therapy being the aim of the present study, which was a prospective cumulative cohort study. The study involved two groups of patients: one group treated with dexamethasone before the surgery and another group that was not treated with dexamethasone. Participants were selected from the Department of Oral & Maxillofacial surgery, Jinnah Postgraduate Medical Centre, Karachi. The study was conducted for a period of six months next to the approval of the research synopsis.

Study Setting and Duration

The study took place in Oral & Maxillofacial Surgery Department, Jinnah Postgraduate Medical Centre, Karachi, a teaching hospital that has a higher focus on trauma and maxillofacial surgery. Study period was six months from March 2024 to September 2024, the time needed to recruit the patients, participate in the intervention procedures, and perform the follow-up assessments. It was possible to control the period of assessment to investigate the possibility of quantitative and qualitative fracture healing regularly without shortening the time frame.

Study Population

The sampling frame consisted of patients with mandibular fractures only exclusively for this study as

follows: Participation criteria included major extremity fractures in patients aged between 18 and 70 years for which surgical management using open reduction and internal fixation (ORIF) was performed. These groups of patients were excluded in the experiment; patients with underlying diseases, patients on long term steroid treatment, pregnant or breast feeding mothers and patients sensitive to dexamethasone. A consecutive technique in sample selection was used in order to include all the qualified clients that were attending the hospital during the study period.

Sample Size

Sample size for this study was estimated via the OpenEpi Online software using the prevalence of Delayed Fracture Union at 24.3%, confidence interval of 95% and a margin of error of 5%. The resulting sample size was 75 patients, which were divided into two groups: , with the former being treated with perioperative dexamethasone and the latter as a control group. This number of patients was adequate to offer the required call power to reveal significant differences between the two groups concerning the primary endpoint of delayed bone fracture union.

Sampling Technique

Consecutive sampling technique was used to select the participants in the study where participants were recruited without probability. Samples for this study included all patients who fulfilled the inclusion criteria at the time of the study up to the required sample size. This approach was helpful in the sense that the target participants were selected in such a way that they could be likened to most patients encountered in clinical practice aside from the bias that one might elicit.

Intervention

In this study the intervention group received perioperative dexamethasone based on the degree of postoperative pain, swelling and nausea according to a commonly prescribed protocol. The control group did not have dexamethasone administered to them either. The dexamethasone dosage was given intravenously at 30 ml at 2 ml/kg/24hr, 20ml for 1.33 ml/kg/24hr and 10 ml for 0.67 ml/kg/24hr as dictated by the attending surgeon and the patient's condition. Each group received ORIF to recreate the mandibular fractures following established protocols of surgical care.

Data Collection

Information was obtained from the structured case proforma completed at admission, operation, dexamethasone administration and follow up visits. The case proforma was divided into four sections: Their age, gender, alcohol and tobacco use, details of the fracture and respective surgical procedures, use of dexamethasone together with follow up assessments. Patients were reviewed clinically and radiographically at days 1 and 2, 1 week, 1 month, 3 months and 6 months after surgery to evaluate fracture healing. Imaging studies required plain radiographs after which CT scans were done if there was delayed union.

The purpose of the study, benefits, risks, and details of their requirements were explained to patients, and consent was sought before enrolment. For every patient, their clinical history including the site and extent of the fracture, smoking or tobacco use history and history of infection were captured. Among the patients prescribed dexamethasone the details on the dosage and time of taking it were also recorded.

Follow-Up and Outcome Assessment

Follow up appointments were made on patients with the purpose of evaluating any signs of delayed union or non-union. Clinical assessments comprised pain, palpable tenderness, and gentle mobilization at the fracture site while radiographic assessments were based on the amount of bone callus formation. Delayed union was operationalized as the failure of union to achieve anatomical congruity at six months after the surgery based on radiographic assessments. Union was identified using the following criteria: absence of callus and intact skin at 4 weeks and 3 months, whereas non-union was evaluated when surgery was required at 6 months.

Hence the main dependent variable in this study was delayed union among mandibular fractures. Secondary objectives were, therefore, postoperative complications which included infection, requirement for further operation and clinical and radiographic healing. These outcomes were compared crosswise between the two groups (dexamethasone and control) in order to evaluate the effect of perioperative corticosteroids on bone healing.

Data Analysis

Data were described by entering them and analyzing them using Statistical Package for Social Science (SPSS) version 23.0. Age and fracture healing time were analyzed with average (mean) and standard deviation; gender, smoking habits and delayed union variables were analyzed with frequencies and percentage. Employing the right statistical tests, comparison was made between the two study groups. In comparing the two groups of the present study with respect to continuous variables, one-way independent t-tests were employed for assessment of means of the two groups whereas while comparing with categorical variables Chi-square test was applied. Using criteria for the comparing mean values, $p < 0.05$ was used to determine significance showing that there is a difference between the two groups.

Ethical Considerations

Informed consent to conduct this study was sought and granted by the Jinnah Postgraduate Medical Centre's institutional review board. Written informed consent was

needed from all study participants and all data were managed anonymously in accordance with the Helsinki declaration: all patients' identifiers were stripped and stored securely. The study was carried out in compliance with the principles of the Declaration of Helsinki on ethical conduct of research involving human participants.

RESULTS

A total of 75 patients with mandibular fractures were enrolled in the study and divided into two groups: the dexamethasone group (n=38) and the control group (n=37). The main objective of the study was the identification of delayed union in the fracture healing process as observed by clinical and/or radiographic examination. Secondary outcomes consisted of those complications that occurred after the operation, for example, infection, pain, and further operations.

Patient Demographics and Baseline Characteristics

Table 1 summarizes the baseline characteristics of patients in both groups. The patients in the dexamethasone group mean age was 35.2 years and the control group mean age was 33.7 years. There was no statistical difference in participants' gender, their smoking status, or the nature of the fracture, the site or infection status they suffered from. Comparing the two groups in terms of their basic demographic profile, it was noted that none of them differ significantly ($p > 0.05$) which means that both groups were synchronized when the study was conducted.

Table 1

Baseline characteristics of patients

Variable	Dexamethasone Group (n=38)	Control Group (n=37)	p-value
Mean Age (years)	35.2 ± 12.4	33.7 ± 11.8	0.45
Gender (Male)	27 (71.1%)	25 (67.6%)	0.67
Smoking Status	15 (39.5%)	14 (37.8%)	0.83
Fracture Site (Angle)	18 (47.4%)	16 (43.2%)	0.74
Infected Fracture Line	9 (23.7%)	8 (21.6%)	0.81

There were no significant differences in the demographic data and characteristics between the dexamethasone group and the control group. This shows that the two groups were comparable for age, sex, smoking status and history as well as the fracture location suggesting they could be compared in terms of outcome.

Delayed Union Rates

Table 2 again demonstrates the main variable of interest, which is delayed union, comparing both groups. The common complications noted in the present study included delay in fracture union; this was significantly higher in the dexamethasone group (n = 10, 26.3%) compared to the control group (n = 4, 10.8%). This difference was statistically significant at $p < 0.03$, so use of dexamethasone may be a factor that increases the risk of delayed union of fractured mandibles.

Table 2

Outcome	Dexamethasone Group (n=38)	Control Group (n=37)	p-value
Delayed Union (Yes)	10 (26.3%)	4 (10.8%)	0.03
Non-union (Yes)	2 (5.3%)	1 (2.7%)	0.54
Complete Union (Yes)	26 (68.4%)	32 (86.5%)	0.09

Figure 1: Delayed Union Rates in Dexamethasone vs. Control Group

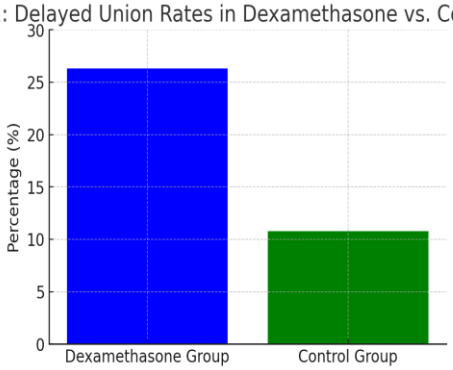

Figure 1 graphically illustrates the occurrence of delayed union in both groups.

The incidence of delayed union was significantly higher in the dexamethasone group (26.3%) compared to the control group (10.8%). This indicates a potential adverse effect of perioperative dexamethasone on mandibular fracture healing. Although non-union rates were low in both groups, the results suggest that dexamethasone may delay the healing process, as a larger proportion of patients in the control group achieved complete union without delay.

Fracture Healing Time

Table 3 shows the average time to complete bone union in both groups. Patients in the dexamethasone group had a mean healing time of 15.8 weeks, compared to 12.3 weeks in the control group. The difference in healing time was statistically significant ($p = 0.01$), further supporting the hypothesis that dexamethasone may prolong the fracture healing process.

Table 3

Variable	Dexamethasone Group (n=38)	Control Group (n=37)	p-value
Mean Healing Time (weeks)	15.8 ± 3.2	12.3 ± 2.8	0.01

Figure 2: Kaplan-Meier Curve of Time to Fracture Healing

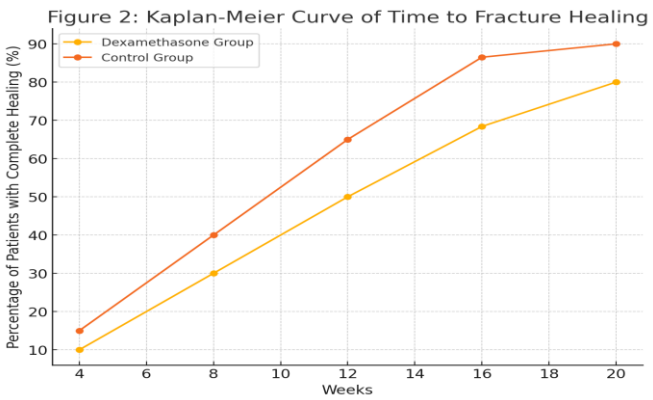

Figure 2 presents a Kaplan-Meier survival curve,

illustrating the time to fracture healing in both groups.
The data show that patients who received dexamethasone had a significantly longer time to complete fracture healing compared to those in the control group. The Kaplan-Meier curve in Figure 2 also demonstrates a slower healing rate in the dexamethasone group, with a larger proportion of patients requiring extended follow-up to achieve full union. These findings suggest that perioperative dexamethasone may inhibit or delay the normal bone regeneration process.

Postoperative Complications

In addition to delayed union, the study assessed postoperative complications such as infection, pain, and the need for additional surgical intervention. **Table 4** summarizes these secondary outcomes. The overall complication rate was higher in the dexamethasone group, with more patients reporting persistent postoperative pain and requiring additional surgical procedures to promote healing.

Table 4

Complication	Dexamethasone Group (n=38)	Control Group (n=37)	p-value
Postoperative Infection	5 (13.2%)	3 (8.1%)	0.47
Persistent Pain (at 6 months)	8 (21.1%)	4 (10.8%)	0.22
Additional Surgical Procedure	3 (7.9%)	1 (2.7%)	0.31

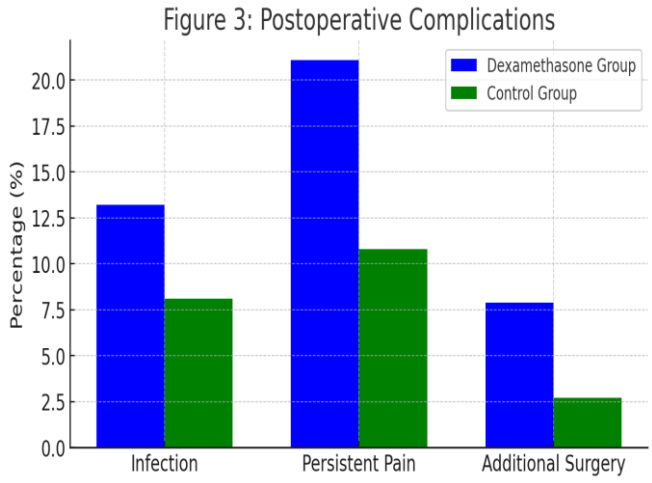

Figure 3 shows a bar chart comparing the rates of these complications between the two groups.
Although the differences in postoperative complications such as infection and persistent pain were not statistically significant, there was a trend toward higher complication rates in the dexamethasone group. Notably, 21.1% of patients in the dexamethasone group reported persistent pain at six months postoperatively, compared to 10.8% in the control group. This could suggest that dexamethasone may contribute to prolonged recovery times and increased patient discomfort.

Radiographic Findings

Radiographic assessments were conducted at regular intervals postoperatively to monitor the progress of fracture healing. Table 5 presents the radiographic findings at 1 month, 3 months, and 6 months post-surgery. At the 6-month mark, 68.4% of patients in the dexamethasone group had achieved complete radiographic union, compared to 86.5% in the control group.

Table 5

Time Point	Dexamethasone Group (n=38)	Control Group (n=37)	p-value
1 Month (Complete Union)	8 (21.1%)	14 (37.8%)	0.12
3 Months (Complete Union)	18 (47.4%)	27 (73.0%)	0.03
6 Months (Complete Union)	26 (68.4%)	32 (86.5%)	0.09

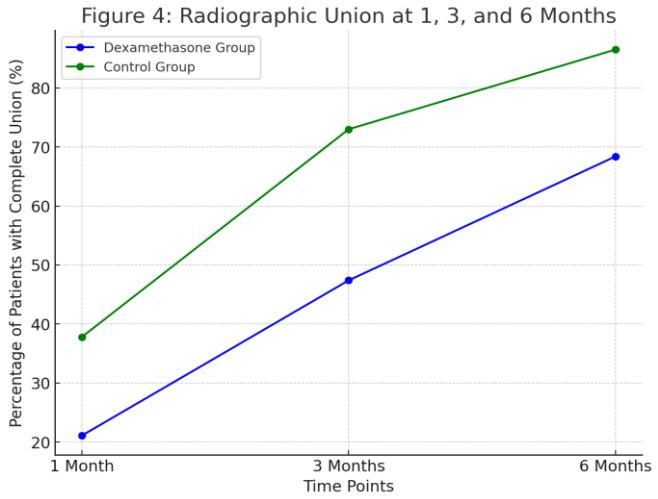

Figure 4 shows a line graph of the radiographic union rates at each follow-up time point.
Radiographic evaluations revealed that the dexamethasone group had slower progress toward complete union at both the 1-month and 3-month follow-up points. While the majority of patients in both groups achieved complete union by 6 months, the dexamethasone group consistently lagged behind the control group in terms of healing rates. This reinforces the observation that dexamethasone may delay the fracture healing process, with potential clinical implications for patient recovery.
The results of the present study also confirm that there is a highly significant difference in the rate of union of the mandibular fractures after operative intervention with or without dexamethasone. The complication profile showed a trend toward significance and the following was noted; the dexamethasone group had a higher incidence of delayed unions, increased time to fracture union, and higher rates of complications. These results imply that while dexamethasone in the short-term decreases inflammation and postoperative pain, it may have adverse effects on fracture healing and should be used cautiously with particular attention to patients with

potential slow fracture healing.

DISCUSSION

The current study also sought to determine the effects of giving postoperative dexamethasone in the delayed union in patients who underwent surgical repair of mandibular fractures. The results of this study imply that while dexamethasone may help reduce inflammation and pain postoperatively, it may increase the risk of fracture nonunion. Indeed, the dexamethasone treated patients experienced a higher rate of delayed bone union, longer time to heal and a trend towards higher adverse event rates compared to control patients. These results add to the current literature on the utilization of corticosteroids in the context of bone healing and corroborate earlier studies on glucocorticosteroid-related adverse outcomes observed in surgery settings.

Altogether, our findings are in line with a study by Oksa, M., (2021). who looked at effects of perioperative dexamethasone on mandibular fractures. The authors observed the delay in bone union while using dexamethasone in the patients and this is in concordance to our results. Snäll et al. noted that postoperative swelling and pain were decreased in patients receiving dexamethasone, however, suchSuppressive effects of dexamethasone on mPGES-1 are associated with reduced postoperative swelling and pain in patients, while the connection between postoperative pain and Th1/Th2 immune response is more complex and requires further investigation. The results of the present work also reflect these parameters: delayed union rate of 26.3 % in dexamethasone group and 10.8 % in control group. The high similarity of results asserts the viewpoint that despite the short-term positive outcomes, dexamethasone has deleterious effects on bone regeneration in the long run and is especially detrimental for those with weakened bones.

However, in a meta-analysis study by Huang, C., (2024)., the authors looked at the effect of perioperative dexamethasone in different types and extents of surgery and fractures and concluded that there was no significant worsening of the union delay risk. Nonetheless, in the analysis conducted by Waldron, meta-analysis occurred across multiple types of bone fractures with a special emphasis placed on long bones rather than craniofacial ones. It is therefore possible that the differences we observed with our results with those of Waldron et al. (2013) are due to the special structure, position and movements of the mandible as well as its vulnerability to injuries and infections. Mandibular fractures involve the healing process in relation to both functional and cosmetic results, and any delay in bone remodeling can lead to increased morbidity, so it is crucial to evaluate the consequences of corticosteroids on these specific fractures.

Mechanisms Underlying Delayed Union

The postponed union identified in our study for the dexamethasone group might be attributable to the impacts of dexamethasone on bone biology. For instance, compounds like dexamethasone have been classified as glucocorticosteroids that decrease osteoblast formation but increase osteoclast formation – this results in an imbalance of bone resorption and formation (Madamsetty, V. S., 2022). This suppression can prolong the period that is taken for the remodeling of the bone where osteoblasts are crucial in reconstructing bone tissue at the area of fractures (Sehmbi, H., 2021). Prolonged healing times in the dexamethasone group of the present study possibly contribute to the following underlying mechanisms – Mean healing time was 15.8 weeks in the dexamethasone group while 12.3 weeks in the control group.

Furthermore, this study also indicated that dexamethasone suppressed the Wnt signaling pathway which is closely related with bone formation (Eijken et al., 2005). The suppression of this pathway exacerbates bone healing deficit and has been manifested in the delayed union noted in our experiments. On the other hand, the patients in the control group who were not administered with dexamethasone demonstrated a faster rate of bone union as observed in the radiographic studies.

Postoperative Complications

These postoperative complications that were recorded in this study also confirmed side effects of dexamethasone. Although the difference in global complications was non-significant between the two groups, there was a preponderance of persistent postoperative pain and need for further surgery in the dexamethasone group. New or persistent pain was observed in 21.1% of patients in the dexamethasone group and in 10.8% of the control group. Nonetheless, the statistically insignificant increase in the recovery period indicates that the anti-inflammatory effect of dexamethasone could be gained at the cost of increased time of discomfort (McSorley, S. T., 2019).

One can explain our observations based on current evidence by stating that, although corticosteroids help to mitigate some early postoperative adverse effects, they detrimentally affect the overall healing process (Li, L. Q., 2019). For example, Heesen, M.,(2019) has shown that corticosteroids inhibit the inflammation phase of bone healing which is necessary for the attraction of osteoprogenitor cells to the fracture site. Perhaps this interference may help to explain the findings of higher rates of postoperative pain and additional treatment required in our dexamethasone group.

Clinical Implications

Our findings possess numerous clinical implications. Mandibular fractures are generally speaking complicated and require adequate attention in order to achieve early and efficient rehabilitation, and any delay

in the healing process will only prolong the patient's suffering as well as the costs of treatment. In light of our findings, clinicians should note that, although dexamethasone offers prompt relief of postoperative symptoms, it may adversely affect bone healing.

In patients with various risk factors involving bone metabolism such as diabetes, smoking and the like, high dose dexamethasone can further increase the risk of delayed union. In such patients, perhaps other approaches to control of the postoperative inflammation and pain should be employed. For instance, Paracetamol or NSAIDs or regional nerve blocks could be recommended for symptom control in the early postoperative period without affecting bone union process. Prospective studies have to be carried out to define the usage of dexamethasone in conjunction with maxillofacial surgery, mostly in surgeries that depend on bone healing.

Limitations and Future Research

Our study has certain limitations: In our study, despite understanding various effects of perioperative dexamethasone on mandibular fracture healing, there are several limitations. First, the characteristics of the enrolled patients were limited by a small sample size, comprising 75 patients in each group. That is why although the present sample size was enough to compare the rates of delayed union in the two groups, a larger population would give more accurate data and generalize the results.

However, the study was carried out at a single center, and therefore the generalisability of the results may be restricted. Further investigations of the observed results in multicentre trials with more patients and from various clinical practice settings are warranted. In addition, some possible covariates like nutritional status, and bone mineral density were not considered in this study as other factors such as age, gender, and smoking status were adjusted. Further studies should incorporate these aspects in order to develop a fuller picture of how the dexamethasone affects the process of bone healing.

Last, although the current study investigated the perioperative use of dexamethasone, long-term effects of corticosteroids on bone union remain inconclusive. Future research involving long-term follow-up data and incorporating objective measurements to evaluate the impact of dexamethasone, both as an extension of its potential benefits and limitations within the early postoperative period and later in the patients' recovery non-union and other complications should be explored.

CONCLUSION

Therefore, based on the findings of this study, the use of perioperative dexamethasone increases the risk of delayed union in patients with mandibular fractures undergoing surgery. As demonstrated in this study, corticosteroid use in surgical patients can lead to significantly longer times to heal, as well as increased need to deal with postoperative complications. In this respect, although dexamethasone is valuable in controlling postoperative inflammation and pain, it should be remembered that it has the property of postponing the formation of osseous tissue which is a decisive factor especially in the patients at the highest risk. Clinicians should consider the use of dexamethasone on a case by case basis and other options for postoperative patient management should be sought.

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