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RESEARCH ARTICLE

EFFECT OF INTERMAXILLARY FIXATION ON BIOCHEMICAL AND BLOOD MARKERS IN A SAMPLE OF YEMENI ADULTS

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Abstract

Background: Intermaxillary fixation is a technique that is used in the treatment of jaw fractures, orthognathic surgery, temporomandibular joint disorders, and occasionally morbid obesity. However, it disrupts normal nutrition, leading to weakened immunity, impaired healing, and higher complication risks, negatively impacting treatment outcomes and patient recovery. Thus, the aim of this study was to investigate the physiological changes in a sample of Yemeni patients following four weeks of IMF treatment.

Materials and Methods: A study involving ten Yemeni adults underwent intermaxillary fixation for mandibular fractures. Parameters like body weight, lipid profile, liver function tests, kidney function tests, electrolytes, and hemoglobin levels were analyzed before and after treatment at a central blood bank.

Results: The majority of patients were male (80.0%) and aged between 25 and 35 years, and the majority had a unilateral mandibular body fracture (50%). Clinical results after 4 weeks of intermaxillary fixation demonstrated significant reductions in body weight (4.2 kg) and BMI (1.0 kg/m^2). post-IMF application, lipid profile analysis showed non-significant changes in total cholesterol, high-density lipoprotein levels, low-density lipoprotein, and triglycerides (p>0.05), liver function tests exhibited significant decreases in AST (7.7 µ/l, p=0.044), kidney function tests and electrolyte analysis revealed non-significant changes, and there were significant reductions in T.WBC (2.48 x 10^9/L) and neutrophils (19.5%) after IMF (p=0.007).

Conclusions: Intermaxillary fixation in Yemeni adults leads to weight loss and changes in liver and blood parameters, indicating its systemic effects. These findings highlight the importance of nutritional support and close monitoring during IMF treatment to mitigate malnutrition risks and optimize healing outcomes.

Keywords: Adults, biochemical markers, blood markers, intermaxillary fixation (IMF), Yemen.

INTRODUCTION

Maxillofacial injuries are extremely common among trauma victims. Research indicates that while road traffic accidents are the primary cause of maxillofacial fractures in underdeveloped countries, falls and insults are the leading causes in industrialized countries[1,2]. The mandible and maxilla are the most often impacted bones in cases of maxillofacial trauma. Several different treatment approaches can be used for fractures of the mandible or midface. Closed reduction using intermaxillary fixation (IMF) is one of them. To guarantee that the fracture segments might fuse in their original placements, this approach establishes the occlusion and maintains the jaws in the same relation[1,3]. Although close reduction via IMF is a widely used technique, it should be noted that it can occasionally result in complications such as malnutrition, nonunion, gingival, and periodontal inflammation[4]. Additionally, IMF interferes with the patient's normal diet intake and nutrition, which is important in the healing process[5,6]. IMF affects body weight, BMI, and other nutrition indices[7,8]. Symptoms of malnutrition include losing more than 10% of body weight, neurologic changes, hair loss, reduction of serum protein, changes in skin, loss of muscle mass, etc. The effects of IMF on a number of paraclinical parameters, including blood indicators, kidney profiles, lipid profiles, and liver enzyme profiles, have been assessed in this study. These variables serve as indicators of internal organ damage and malnutrition, which aids in our decision-making on the best course of action for preventing these conditions using a variety of treatments and dietary supplements. The nutritional limitations imposed by IMF can have detrimental effects on the healing process and overall health, highlighting the need for tailored nutrition plans for patients undergoing this treatment[9,10]. Additionally, each civilization and region has unique dietary and nutrition customs; thus, in order to determine the appropriate course of action, it is imperative to assess how closed reduction will affect the people in each area. Additionally, this work provides a solid basis for future study in an understudied field, laying the groundwork for improvements in patient care and wellbeing in the future. The ultimate goal of this research is to enhance the therapeutic results and quality of life for patients receiving IMF treatment in Yemen and elsewhere.

MATERIALS AND METHODS

This study utilized a prospective randomized clinical trial (RCT) design, conducted within the oral and maxillofacial surgery departments of several teaching hospitals in Sana'a, Yemen. The population comprised Yemeni adults who underwent a four-week intermaxillary fixation (IMF) treatment between 2022 and 2023. A sample size of 10 patients was determined using a formula that accounted for a 20% error rate, resulting in a rounded sample size of 10. Inclusion criteria included patients aged 18 to 50, with isolated maxillofacial injuries, no prior treatment for maxillofacial trauma, and satisfactory healing of fractures post-treatment. Patients with systemic conditions, infected fractures, nutritional supplement intake, or premature IMF removal were excluded, as these factors could significantly influence the study outcomes. Data collection involved both qualitative and quantitative measures, including demographic information, fracture history, and physiological parameters, collected on the day of IMF application and after four weeks. Physiological parameters included body measurements, lipid profiles, liver and kidney function tests, electrolytes, and complete blood count (CBC). All data were analyzed using SPSS, with a significance level set at $p \leq 0.05$. Ethical approval was granted by the Medical Ethics Committee, and informed consent was obtained from all participants, with strict confidentiality maintained throughout the study.

RESULTS

Patient demographics and fracture characteristics: The study cohort consisted predominantly of male patients (80.0%), aged between 25 and 35 years, with the majority (50%) presenting with unilateral mandibular body fractures (Table 1).

Table 1: Frequency distribution of age among patients.

Age	Male N (%)	Female N (%)	Total N (%)
Less than 25 years	1 (10%)	1 (10)	2 (20)
25-35 years	6 (60)	1 (13.5)	7 (70)
36 years or older	1 (10)	0 (0)	1 (10)
Total	8 (80)	2 (20)	10 (100)

Body Weight and BMI: A significant decrease in both body weight and BMI was observed post-IMF treatment. The mean body weight decreased from 58.9±13.15 kg before IMF to 54.7±13.75 kg after the treatment, with a mean difference of 4.2 kg (p=0.000). Similarly, BMI reduced from 20.9±3.67 kg/m² to 19.8±4.35 kg/m², indicating a statistically significant mean difference of 1.0 kg/m² (p=0.048). These findings suggest a potential risk of malnutrition, which is a critical concern during IMF treatment (Table 4).

Table 2: Occupation distribution among patients.

Occupation	N (%)
Student	4 (40)
Employee	2 (20)
Teacher	1 (10)
Motorcycle driver	1 (10)
Worker	1 (10)
Guard	1 (10)
Total	10 (100)

Liver Function Tests: Liver function was assessed using various markers, including Total Bilirubin (T. Bill), Direct Bilirubin (D. Bill), Alkaline Phosphatase (ALP), Albumin, and liver enzymes (ALT, AST). Although there was a slight decrease in T. Bill from 10.2 to 8.9 µmol/L (p=0.374) and in D. Bill from 3.61 to 2.88 µmol/L (p=0.367), these changes were not statistically significant, indicating stable liver function. The ALT levels decreased notably from 46.8 to 22.2 µ/L (p=0.129), while AST levels showed a statistically significant reduction from 32.1 to 24.4 µ/L (p=0.044), suggesting an improvement in liver health during IMF (Table 5).

Table 3: The primary healing outcome distribution among patients.

Primary healing outcome	N (%)
Satisfactory healing	10 (100)
Unsatisfactory healing	0 (0)
Total	10 (100)

Table 4: Effect of IMF on mean body measurements.

Body measurements	On the day of IMF				On the fourth week after IMF				Mean Difference	*p*-value
	Mean	SD	Min	Max	Mean	SD	Min	Max		
Body weight (kg)	58.9	13.15	37	78	54.7	13.75	31	71.5	-4.2	0.000*
BMI (kg/m2)	20.9	3.67	15.4	27.5	19.8	4.35	12.9	25.9	-1.1	0.048*

Note: * is significant in comparison with the initial values (* = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$).

Table 5: Effect of IMF on the mean of liver function tests and protein concentration.

Liver function tests	On the day of IMF				4 or 6 weeks after IMF				Mean Difference	*p*-value
	Mean	SD	Min	Max	Mean	SD	Min	Max		
T. Bill (µmol/l)	10.2	5.57	4.2	20	8.9	4.57	3.1	15.1	-1.3	0.374
D. Bill (µmol/l)	3.61	3.88	0.8	11	2.88	0.93	1.5	4.2	-0.73	0.367
ALP (u/l)	104.5	50.45	63	235	104.2	51.50	66	229.5	-0.3	0.953
Alb (g/l)	43.6	5.57	34.9	51.3	44.6	3.44	40.1	50.0	1.0	0.712
ALT (µ/l)	46.8	61.07	12	212	22.2	17.4	10	68	-24.6	0.129
AST (µ/l)	32.1	14.18	19.2	58	24.4	9.67	18	46	-7.7	0.044*
GGT (µ/l)	35.1	19.52	15.3	66	25.8	15.54	12	59	-9.3	0.123
TP (g/l)	68.8	8.78	52.2	79.9	70.6	5.43	61	81	1.8	0.661

Note: * = significant in comparison with the initial values (* = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$).

Lipid Profile: The lipid profile, which includes Total Cholesterol (TC), HDL, LDL, and triglycerides (TG), showed variations post-IMF treatment. TC increased slightly from 209.3 to 217.8 mg/dL (p=0.738), while HDL decreased from 49.7 to 45.8 mg/dL (p=0.205). LDL levels rose from 133.5 to 143.8 mg/dL (p=0.576), and TG levels decreased marginally from 138.0 to 131.9 mg/dL (p=0.824). Despite these changes, none reached statistical significance, indicating that IMF treatment did not substantially impact the lipid profile in a clinically meaningful way (Table 6).

Table 6: Effect of IMF on the lipid profile.

Lipid profile	On the day of IMF				4 or 6 weeks after IMF				Mean Difference	*p*-value
	Mean	SD	Min	Max	Mean	SD	Min	Max		
TC (mg/dl)	209.3	74.0	117	332	217.8	53.50	113	320	8.5	0.738
HDL (mg/dl)	49.7	9.78	37	69	45.8	7.43	36	57.9	-3.93	0.205
LDL (mg/dl)	133.5	54.9	57.2	230	143.8	48.1	64.1	221.4	10.3	0.576
TG (mg/dl)	138.0	95.0	40	340	131.9	33.3	92	192	-6.15	0.824

Note: * is significant in comparison with the initial values (* = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$).

Kidney Function and Electrolytes: Kidney function was evaluated using uric acid, urea, and creatinine levels, which remained stable throughout the IMF treatment. Uric acid levels increased from 307.9 to 330.5 mmol/L (p=0.321), and creatinine levels rose slightly from 65.5 to 66.7 mmol/L (p=0.821), neither of which were statistically significant. Similarly, electrolyte levels potassium (K+) and sodium (Na+) showed minor changes, with K+ increasing from 3.98 to 4.11 mmol/L (p=0.246) and Na+ decreasing from 141.1 to 140.6 mmol/L (p=0.727), both without statistical significance (Table 7 and Table 8).

Table 7: Effect of IMF on the mean of kidney function tests.

Kidney function tests	On the day of IMF				4 or 6 weeks after IMF				Mean Difference	*p*-value
	Mean	SD	Min	Max	Mean	SD	Min	Max		
Uric acid (mmol/l)	307.9	61.15	203	398	330.5	77.13	181	453	22.6	0.321
Urea (mmol/l)	4.34	1.95	2.3	7.8	3.48	1.74	1.8	7	-0.87	0.163
Creatinine (µmol/l)	65.5	14.8	40	85	66.7	15.4	44	94	1.2	0.821

Note: * = significant in comparison with the initial values (* = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$).

Table 8: Effect of IMF on electrolytes.

Electrolytes	On the day of IMF				4 or 6 weeks after IMF				Mean Difference	*p*-value
	Mean	SD	Min	Max	Mean	SD	Min	Max		
Serum K+ (mmol/l)	3.98	0.42	3.3	4.6	4.11	0.46	3.5	4.7	0.13	0.246
Serum Na+ (mmol/l)	141.1	6.15	129	153.2	140.6	5.56	131	148	-0.5	0.727

Note: * = significant in comparison with the initial values (* = $p<0.05$; ** = $p<0.01$; *** = $p<0.001$).

Hematological Parameters: The hematological assessment revealed a decrease in Hemoglobin (Hb) from 14.9 to 14.6 g/dL (p=0.374) and a significant reduction in White Blood Cell (WBC) count from 7.86×10^6 L to 5.48×10^6/L (p=0.007). Neutrophil percentage (NEU%) also declined significantly from 59.7% to 40.2% (p=0.007). These findings suggest an immunological response to IMF, which may have clinical implications for patient monitoring during treatment (Table 9).

Interpretation and Clinical Relevance: While several changes observed in this study were statistically significant, their clinical relevance varies. For instance, the reduction in body weight and BMI is clinically significant due to the associated risk of malnutrition, necessitating nutritional intervention.

In contrast, changes in lipid profiles and liver function markers, despite some statistical significance, may not have immediate clinical implications but highlight areas for further monitoring during IMF treatment.

DISCUSSION

When patients with jaw fractures receive particular treatment (such as surgeries or jaw fixation for 4-6 weeks), their metabolisms change significantly, which increases their need for nutrients in addition to their already low dietary intake[11]. This is because post-traumatic catabolism develops in these individuals. Loss of fluid and electrolytes, muscle breakdown, lipolysis, proteolysis, and a negative nitrogen balance are all repercussions of the metabolic response to trauma that cause a fall in body weight that, depending on the data, can range from 3 to 9 kg in 1-1.5 months[11-14]. The four-week immobilization period necessitates adherence to a liquid diet, which is known to result in insufficient nutritional intake. In our study, the entire sample exhibited a significant reduction in body weight, with an average loss of approximately 4.2 kg post-IMF treatment.

Table 9: Effect of the IMF on the mean of CBC values.

CBC	On the day of IMF				4 or 6 weeks after IMF				Mean Difference	*p*-value
	Mean	SD	Min	Max	Mean	SD	Min	Max		
Hb (g/dl)	14.9	1.55	11.8	16.5	14.6	1.89	10.4	16.4	-0.3	0.374
T.WBC (x 10^9/L)	7.86	3.41	4.87	15.26	5.38	1.89	2.71	8.59	-2.48	0.007*
TLC %	41.04	8.83	30.0	56.0	40.97	11.40	19.0	54.0	-0.07	0.987
NEU%	59.7	19.67	39	89	40.2	15.57	15.7	65	-19.5	0.007*

This finding suggests that immobilization may have a notable impact on metabolic processes and nutritional status. This observation aligns with existing literature, where similar reductions in body weight following IMF have been documented. For example, Simon *et al.*[15], reported an average weight reduction of 3.4 kg after four weeks of IMF, while Zaidi's study[16] indicated a significant weight loss of 2.571 kg following the same duration of treatment. Hino *et al.*[17], also demonstrated a weight reduction of 2.74 kg, while Popat *et al.*[18], observed a decrease of 3.82 kg after four weeks of IMF treatment. The observed decrease in weight and BMI raises concerns about potential risks, such as malnutrition, sarcopenia, and a compromised immune response, all of which are critical during the IMF treatment phase. Consequently, a comprehensive nutritional assessment and intervention strategy are essential for the holistic care of individuals undergoing IMF.

Regarding liver function tests, our study revealed that AST levels showed a statistically significant decrease from 32.1 µ/L to 24.4 µ/L (p=0.044), suggesting that IMF treatment may have a beneficial effect on reducing AST levels. Additionally, these findings hint at the potential benefits of Qat cessation on liver function. Chronic Qat chewing has been linked to subclinical hepatocellular damage[19], and its discontinuation could potentially alleviate liver stress. Notably, no previous studies have specifically investigated AST level changes in the context of IMF therapy.

Current study also identified a significant decrease in total white blood cell (T. WBC) count and neutrophil percentage post-IMF treatment. This could be attributed to the body's adaptation to reduced inflammation or decreased immunity resulting from inadequate dietary intake during the immobilization period. These findings are consistent with the results of Dueñes Greyner[20] and Turdikulovna *et al.*[21], who similarly reported a significant reduction in T.WBC.

Protein loss can exceed 25 grams per day in cases of severe injuries to the bones that make up the face skeleton. It should be noted that active synthesis of "acute phase" proteins, as opposed to organ proteins, predominates in the liver. Visceral proteins including albumin and transferrin therefore have a sharp decline in concentration[22]. Some authors have reported statistically significant declines in blood albumin levels over the immobilization period[12,13,23]. However, in the present investigation, no significant alterations were detected in serum protein and albumin levels following IMF treatment. This observation may be attributed to the possibility that the globulin fraction could counterbalance any changes, potentially leading to an increase in total protein levels. Such a condition is likely a result of underlying catabolic processes. Similar outcomes were reported by Elamin[24] and Kondo *et al.*[25], where both studies observed an insignificant rise in serum total protein levels. Additionally, Elamin[24] and Christensen *et al.*[26], found an insignificant increase in serum albumin levels. However, these findings contrast with most of the literature, which generally reports a significant decrease in total protein and albumin levels following IMF treatment. However, our study reported non-significant changes in kidney function tests (uric acid, urea, and creatinine), electrolyte levels (sodium and potassium), and hematology parameters (hemoglobin and total lymphocyte count). These discrepancies between our findings and those of other studies may be attributed to variations in the dietary regimen prescribed during IMF treatment.

When employing IMF, it is crucial to provide sufficient nutritional support throughout the fixation period to avert malnutrition and promote optimal healing. This necessitates the inclusion of foods that are high in complete proteins, unsaturated fats, and essential vitamins and minerals. Future research should focus on enhancing nutritional interventions and evaluating their efficacy in Yemeni patients undergoing IMF to reduce weight loss and improve treatment outcomes.

Limitations of the study

Firstly, challenges in patient follow-up led to the exclusion of 8 out of the initial 18 participants, either due to inadequate follow-up or the premature removal of IMF. Secondly, patients who underwent IMF treatment for periods shorter or longer than the prescribed 4 weeks were also excluded. As a result, the study's findings may not fully reflect the physiological changes in these excluded patients, potentially limiting the generalizability of the study. Additionally, the study's sample size was predetermined, influenced by the difficulty in recruiting a larger number of trauma patients treated with IMF, particularly given the prevailing preference for ORIF as the primary treatment method in Sanaa City and the limited time available to complete the master's thesis.

CONCLUSIONS

This study examined the effects of IMF treatment on various physiological parameters and identified key outcomes. IMF led to a notable reduction in body weight and BMI, indicating a potential risk of malnutrition. While changes in lipid profiles were observed, they lacked consistent statistical significance. Liver and kidney functions, as well as electrolyte levels, remained stable, with a slight improvement in liver health suggested by decreased AST levels. Hematological assessments showed a decline in certain white blood cell counts. These findings highlight the importance of nutritional support and close monitoring during IMF to prevent malnutrition and enhance healing, emphasizing the need for comprehensive nutrition plans and careful monitoring of blood parameters to guide supplementation strategies.

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AUTHOR’S CONTRIBUTIONS

Homaid WAHA: Formal analysis, conceptualization, data organization, and clinical and laboratory examinations to obtain a master’s degree in dental sciences. **Nasher AT:** Methodology, formal analysis, visualization. **Al-Shamahy HA:** supervision. **Ahmed STA:** critical review, supervision. **Mabkhout ANA:** clinical work supervision. **Khalid BSM:** editing. **Al-Ankoshy AAM:** critical review. All authors reviewed the article and approved the final version.

DATA AVAILABILITY

The accompanying author can provide the empirical data that were utilized to support the study's conclusions upon request.

CONFLICT OF INTEREST

There are no conflicts of interest in regard to this project.

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