A comparative study between stainless steel and titanium mini plate fixation in fracture of mandible

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INTRODUCTION

The development and application of bone plating to the maxillofacial skeleton has revolutionized the operative management of trauma and reconstructive surgery. Non compression monocortical miniplate fixation of the mandible is an accepted and reliable method for providing semi rigid internal fixation.

In the 21st century many other systems have been introduced such as locking plates¹, bio-absorbable plates², THORP³, microplates⁴, 3-D plates⁵ etc. But due to its number of advantages; such as: less bulk; no need for wide exposure; good stability; easy availability; handling properties; economical; Miniplate system is widely used amongst most of the oral and maxillofacial surgeons and a standard procedure in routine clinical practice⁶.

With the current expanded use of biomaterials for mandibular fracture, the hardware is often left in place indefinitely because removal of these devices would often require additional surgery. Stainless Steel, cobalt-chromium alloys, and Titanium are the metals most commonly used for rigid fixation. Other biocompatible metals include tantalum and nitinol.

The miniplates broadly used are; Stainless steel miniplates & Titanium miniplates.

Here we present a comparative study of fixation, with Stainless Steel miniplates and Titanium miniplates, undertaken for fractures of mandible. The study was carried out for adaptability, effect on fracture line, cost, complications, etc. at Oral & Maxillofacial Surgery Dept. of K.M. Shah Dental College & Hospital, Piparia, Vadodara.

MATERIALS AND METHODS

A prospective randomized clinical study was conducted to compare the efficacy of stainless miniplate fixation with titanium miniplate fixation in fracture of mandible. In which 20 cases who sustained fracture of mandible were selected out of all cases; reported from November 2006 to May 2009.
Patient’s selection was based on following criteria:

- Oblique fractures as well as straight fractures of mandible
- Fractures of the symphysis, parasympythesis, body or angle region associated or unassociated with subcondylar fractures.
- Mandibular fracture associated with fractures of any other facial bone.
- Patients with mandibular fracture who opted to have unrestricted jaw movements.
- No preference to either sex or age was given in adult patients.

Exclusion criteria:

- Children
- Isolated condylar fractures.
- Non-united fractures
- Malunited fractures
- Mandibular comminuted fractures
- Mandibular fracture in medically unfit patient.

All these patients were managed by open reduction & direct internal fixation using either stainless steel or titanium miniplates. The patients were operated under local or general anesthesia by appropriate approach to the fracture site either intraoral or extraoral. As the cost of Champy bone plate set is quite high, ingeniously manufactured bone plating set which resembled the most of their foreign counterparts was selected for the present study. All instruments in each bone plate set were from same manufacture & of the same metallic composition.

The chemical composition of the stainless steel instruments and miniplates as well screws used is according to stainless steel AISI 316 A compositions. Commercially pure titanium with 99.27% of titanium by weight and the rest made of iron, carbon, nitrogen and hydrogen is used for titanium miniplates. Titanium alloy (Ti Al6 V4) with 90% of titanium by weight is used for titanium screws.

The method of treatment comprises of following steps:

- Preoperative assessment & preparation of patients
- Surgical procedure
- Post-operative management

- Follow up and aftercare of the patients

**Figure 1: Stainless steel miniplate in position**

**Figure 2: Titanium miniplate in position**

Statistical analysis:
Statistical analysis was done with (chi-square) test and independent sample ‘t’ test; using SPSS software, VERSION 12.

**RESULTS**
This study was conducted on 20 patients having fracture of mandible with 32 fractures. Of which Stainless Steel miniplates were used in 10 patients & Titanium miniplates were used in 10 patients.

In Stainless Steel group maximum period required was 35 min; while in Titanium group it was 15 min. Statistical analysis showed p= 0.049 (<0.05) stating that distribution of study subjects according to time period required for adaptation and fixation of miniplates was significant.

In Stainless Steel group good adaptation was achieved in 4 (40%) patients; while in Titanium group 100% of good adaptation was achieved (10 patients). Statistical analysis showed p= 0.003 (<0.05) stating that distribution of study subjects according to adaptation of miniplates was significant.
TABLE 1: Distribution of study subjects according to time period required to adapt and fix the miniplates

<table>
<thead>
<tr>
<th>MINIPLATE</th>
<th>TIME PERIOD REQUIRED IN MINUTES</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Titanium</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>

MINIPLATE | TIME PERIOD REQUIRED IN MINUTES | TOTAL |
Stainless Steel | 0.0% | 0.0% | 40.0% | 40.0% | 10.0% | 10.0% | 100.0% |
Titanium | 10.0% | 40.0% | 50.0% | 0.0% | 0.0% | 0.0% | 100.0% |

Total | 5.0% | 20.0% | 45.0% | 20.0% | 5.0% | 5.0% | 100.0% |

TABLE 2: Distribution of study subjects according to adaptation of the miniplates to contour of mandible

<table>
<thead>
<tr>
<th>MINIPLATE</th>
<th>ADAPTATION</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>FAIR</td>
<td>6</td>
</tr>
<tr>
<td>Titanium</td>
<td>60.0%</td>
<td>40.0%</td>
</tr>
<tr>
<td>Titanium</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>0.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MINIPLATE</th>
<th>ADAPTATION</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>FAIR</td>
<td>6</td>
</tr>
<tr>
<td>Titanium</td>
<td>30.0%</td>
<td>70.0%</td>
</tr>
</tbody>
</table>

Figure 1: Distribution of study subjects according to reduction of the fracture fragments maintained with miniplates.

In Stainless Steel group good immediate stability was seen in 8 (80%) patients; while in Titanium group 100% of good immediate stability was maintained (10 patients). Statistical analysis showed p= 0.136 (>0.05) stating that distribution of study subjects according to immediate stability of the fracture fragments maintained with miniplates was insignificant.

Figure 2: Distribution of study subjects according to post operative complications encountered

No cases of infection, non-union or mal-union, plate rejection or mucosal pigmentation were noted in any group. In stainless Steel group; 2 (20%) patients while In Titanium group 3 (30%) patients had post operative occlusal derangement. Suture dehiscence was noted in
one patient of SS group. Paresthesia was noted in 2 (20%) patients of SS group and in 1 (10%) of Titanium group. Plate was palpable in 3 (30%) patients of SS group and in 1 (10%) patient of titanium group. Statistical analysis with test showed p= (> 0.05) with each of these parameters stating that distribution of study subjects according to post operative complications was insignificant. Independent sample t test was performed to perform statistical analysis of cost factor. For per screw cost p= 5.86480682289546E-19 (<0.01) and for per plate cost p= 4.5041389496134E-09 (<0.01); which are highly significant.

**DISCUSSION**

The results of this study confirm those of previous studies, particularly regarding age and sex of the patients. The male female ratio was 9:1. Maximum patients were of age group 21yrs to 30yrs. Parasympysis region had the maximum incidence (17 patients, 53.12%). The incidence noted with angle (5 patients, 15.62%) and sub-condylar regions (6 patients, 18.75%) were less than parasympysis. None of the patients reported with Symphysys fracture. Compound fractures were found in 9 (90%) patients of Stainless Steel group and 10 (100%) patients of Titanium group (p= 0.305). In Stainless Steel group 8 (80%) fractures and in Titanium group 6 (60%) fractures were unfavorable (p= 0.329). Preoperative occlusal disturbance was found in 7 (70%) patients in stainless steel group and in 9 (90%) patients in titanium group.

Out of 20 patients only 1 patient (5%) was treated with intra-oral approach. The rest of 19 patients were treated by extra-oral approach. 15 patients (75%) were treated under general anesthesia and 5 (25%) patients were treated under local anesthesia. According to Kruger and Schilli, intra-oral approach is preferable for open reduction of mandibular fractures. Its advantages are: access for inspecting the occlusion all the time, less chances of facial nerve damage, & better esthetics due to avoidance of extra-oral scar. However where there is gross displacement, extra-oral approach is preferred to access reduction at lower border of mandible.

We found extra-oral approach very convenient to both patient and surgeon and can be used under local anesthesia also. Wound care becomes easy and scar can be minimized using submandibular incision and finer suture materials (5.0 prolene). Avoidance of injury to mental nerve also becomes easy to prevent post-operative paresthesia and placement of miniplate as well as drilling of holes for screw insertion facilitated. Length of the mini plates used and no. of miniplates used were decided according to type, site of fracture and surgeon’s decision. Longer miniplates were used when there is oblique fracture, old fracture; two or three bone pieces were present. Distribution of study subjects according to no. of miniplates used showed p= 0.656 (> 0.05); stating that no significant difference was present in it. According to no. of screws used, it was found that p= 0.228. All of the condylar and subcondylar fractures were treated conservatively with MMF of 3 weeks but associated mandibular fractures were treated with miniplates. Biomechanically tensile strength, compressive strength, and modulus of elasticity affect the ease of contouring and adaptability of miniplates to osseous surfaces of the facial skeleton and also affect maintenance of fracture segments in reduced position. Titanium has a high tensile strength (Weber et al., 1990) and a low modulus of elasticity that allows excellent contouring (Lemond and Lucas, 1986 Marsh, 1989). In our study the comparison of time period required for adaptation and fixation of miniplates showed that titanium miniplates are easier to adapt and required less time for the same [p= 0.049 (<0.05)]. Here we found that titanium possess significant properties for maintenance of reduced segments position then stainless steel miniplates (p= 0.025). Immediate stability after both titanium, and stainless steel miniplate fixation was good (p= 0.136 (>0.05)). That confirms mechanical properties of both the metals.

None of the patients encountered post-operative infection. This was supporting the studies done by Champy (3.8%), Ikemura (3%), Smith (2.5%) & Rix et al (0.5%). Strict aseptic protocol for patient management, antibiotic coverage and maintenance of oral hygiene pre-operatively as well as post-operatively may explain the lower rate of post-operative infection. Moreover due to extra-oral approach; oral contamination of sutured wound was avoided.
Post-operative dehiscence was noticed in one patient treated with stainless steel miniplate and none of the titanium cases. It was managed with 5% betadine irrigation and healed well. Post-operative occlusal derangement was noticed in 5 of 20 patients. 3 in titanium group while, 2 in stainless steel group. Occlusal derangement was related with presence of associated subcondylar fracture or parafunctional movements developed by the patient. Post-operative paresthesia was noticed in 3 patients; 2 patients of stainless steel group and 1 of titanium group; which was present before surgery and was due to injury to inferior alveolar nerve by sharp fracture segment. A careful and meticulous surgical technique and use of monocortical screws reduce the risk of injury to neural as well as adjacent tissues.

Adaptation of the miniplate to contour of mandible and maintenance of reduction of the fractured segments play important role in palpability of the miniplates through overlying tissues. In this study palpability of the miniplate was present in 3 patients treated with stainless steel miniplates and in only one patient who was treated with titanium miniplate. It was not complain of the patient. Good suturing by layers produces excellent tissue coverage. But still in our study we did not find any consistent difference between them \( [p= 0.264(>0.05)] \).

Adaptation of stainless steel miniplate was fair in 5 out of 10 patients while it was good in all 10 patients treated with titanium miniplates. Due to its excellent compression strength and lower modulus of elasticity, titanium gives better adaptation to contour of the skeletal surface \( [p= 0.003 (<0.05)] \).

Cost is an important factor in choice of the miniplates. In our study we found that titanium miniplates are costlier than stainless steel miniplates; but at the same time with its higher bio-compatibility becomes a favorable option. None of the patients complained of or exhibited mucosal pigmentation or hypersensitivity reactions. This was confirming the previous studies \( 17,18,19 \). However, no histological examination of the tissues surrounding the miniplates was carried out. None of the miniplates were needed to be removed thus exhibiting their biocompatibility. Thus, avoiding the second operation at the same site benefits the patient \( 19,20,21,22 \).

However, these findings do not coincide with Kim YK, Yeo HH, Lim S C. They reported that visible pigmentation was found in 14% of the patients in the surrounding soft tissues \( 23 \). There has been uncertainty about the removal of the miniplates following satisfactory healing of the jaw fractures.

Matthew & Frame \( 20,21,22 \) explained that, there is no evidence to support the routine removal of titanium as well as stainless steel miniplates because of surface corrosion up to 6 months after implantation.

According to Maningaud \( 24 \) almost 100% Ti released was insoluble, most likely corresponding to metallic particles released during implantation of the plates. Time dependent leakage if exists is negligible and most of the times Ti seems to be inert. Compared to the possible risks of second operation, the removal of miniplates should not be a routine procedure except in the case of complaint of patient and complications. This is further supported by Thoren H. \( 19 \)

**CONCLUSION**

Titanium miniplate is more malleable & more easily and precisely adaptable to the bone as compared to Stainless Steel plate. The plate showed excellent handling properties & good stability of fractured fragments. However, Titanium miniplate is more expensive as compared to Stainless Steel miniplate. In those patients, who are unable to afford treatment with Titanium miniplate, Stainless Steel miniplate can be equally useful.

**REFERENCES**

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