ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at: www.ijdsir.com
Volume – 3, Issue – 3, May - 2020, Page No. : 22 - 40

Comparative evaluation of the treatment outcomes of the Herbert screw versus two miniplates in the open reduction and internal fixation of anterior mandibular fractures

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Citation of this Article: Dr. Mansi Dey, Dr.Harsha Jain, Dr. Amit Gupta, Dr. Rajeev Pandey, Dr. Balram Garg, Dr. Sanjeev Kumar, “Comparative evaluation of the treatment outcomes of the Herbert screw versus two miniplates in the open reduction and internal fixation of anterior mandibular fractures”, IJDSIR- May - 2020, Vol. – 3, Issue - 3, P. No. 22 – 40.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Purpose: To compare the treatment outcomes of the use of Herbert screw versus two miniplates for open reduction and internal fixation of anterior mandibular fractures.

Methods: We did a prospective study on 14 patients with anterior mandibular fractures. The patients were equally divided into two groups as follows: Herbert screw(n=7) and miniplates(n=7). All patients were recalled for follow up at intervals of 2nd, 4th, 6th and 12th week to check for improvement in bite force, reduction in pain intensity, occlusion, paresthesia, edema, interfragmentary mobility, and for any signs of infection or wound dehiscence. Intraoperative reduction in fracture gap was also checked. At 12th week, the reduction in fracture gap was checked to compare the fracture healing between the two groups. Statistical analysis was done, with the statistical significance set at 5% level.

Results: There was no statistical significant difference between the two groups.

Conclusion: The results of this study suggest that there is no significant difference in the treatment outcomes of both the techniques. The use of Herbert screw, which is a minimally invasive technique, can result in postoperative results that are equivalent to the use of two miniplates that are much bulkier.

Keywords: Herbert screw, miniplates, anterior mandible fractures

Introduction

The function of the mandible is to hold the lower teeth in place and help in mastication. Apart from the ear ossicles, it is the only mobile skull bone[1]. Etiologies of mandibular fractures include motor vehicle accidents, interpersonal violence, falls, and sports. They can also occur in the form of pathologic fractures due to weakening of the mandibular bone. The examination, diagnosis and management of mandibular fractures has been described since 1650 BC by an Egyptian papyrus[2]. A number of treatment modalities have been developed since 1970s for the treatment of anterior mandibular fractures, such as wirings, dynamic compression plates, eccentric dynamic compression plates, miniplates, microplates, three-dimensional(3D) plates, locking plates, resorbable plates, lag screws, Herbert screw, etc[3-8]. The most recent of all these is Herbert screw(Headless Compression Screw) which is a minimally invasive technique that provides compression of the fractured area.

Herbert screw was introduced in the field of Oral and Maxillofacial Surgery mainly to address the disadvantages of the lag screw which was introduced by Brons and Boering in 1970[8]. Initially its use was limited to orthopaedic purposes such as fixation of scaphoid fracture, for which it was proposed for the first time by Herbert and Fisher in 1984[9]. It was also used for treating fractures of the capitellum, and tarsal bones. Initially, the non-cannulated version of Herbert screw was used for providing the compression and stability of the fracture, unless a cannulated form was developed by Whipple for better accuracy during placement[9,10]. It is a headless compressive screw that is mainly placed on the buccal cortical bone and is composed of titanium. The principle on which it works is the same as that of lag screw, but the interfragmentary compression that it produces is much more than that of a conventional lag screw. A lag screw that has been placed to engage the fractured segments has more chances of becoming loose due to instability along the fracture line, which in turn can occur due to the presence of threads on the shaft of the screw. These threads pass through the fractured segments and thus cause instability[11]. Herbert screw, on the other hand, does not contain the threads along the shaft. Instead these are present only at the ends, with the leading end having the threads of larger pitch and smaller diameter and the trailing end having the threads of smaller pitch and a larger diameter. This differential pitch is responsible for the greater amount of compression produce by the Herbert screw[12]. Unlike lag screw, it does not require multiple drill bits and the chances of overdrilling of the osteotomy are also reduced. Passage of the cannulated screw along the guide wire makes the determination of the length of the screw possible. Also, it requires less number of steps for being installed, and the caliber of the osteotomy is also reduced[13].

Herbert screw is quite technique sensitive and requires preoperative planning. This is the reason why the two miniplates, though bulky, are still popular. One of the drawbacks of the absence of the head in the Herbert screw is the difficulty in the removal of the hardware if required at some time in the future. The cause of this difficulty is the bone neoformation around the extremities of the screw[14].

Very few studies have been done to show the use of Herbert screw in the treatment of mandibular fractures. Here we present a prospective, randomized control trial where we compared the improvement in bite force, reduction in pain intensity, postoperative complications and postoperative reduction in fracture gap, with the use of Herbert screw and two miniplates for internal fixation of the anterior mandibular fracture. We hypothesized that there would be statistical significant difference in the clinical and radiographic performances between the two groups after a follow-up of 3 months.

Materials and Method

The study was conducted in the department of Oral and Maxillofacial Surgery at ITS Centre for Dental Studies and Research, Muradnagar, Ghaziabad, Uttar Pradesh, India on the patients attending the outpatient clinic, who came with the history of road traffic accidents, interpersonal violence or sporting injuries. All patients were in the age range of 19-50 years. The duration for the study was from November 2017-19. The patients included in the study were were those who were systemically healthy, having simple or compound fracture in the symphysis or parasymphysis region of the mandible, with dentulous upper and lower arches, no evidence of local infection, no mandibular bone loss and those who were willing to comply with the study procedures, signed the informed consent and were willing to come for follow-up. Patients with atrophic edentulous mandible, with infection in the fracture site, severely comminuted fracture/old fracture/malunion/non-union/pathologic fracture, uncontrolled systemic conditions which would interfere with soft tissue and bone healing(AIDS, diabetes mellitus, bone diseases, bleeding disorders, etc), patients on chemotherapy, radiotherapy that can interfere with bone healing, patients with any history of allergy to the material used in the study and those who were unable/unwilling to come for follow-up or provide informed consent were excluded from the study. 6 out of the 20 patients had lost to follow-up, and hence the study was carried out on 14 patients who were randomly allocated into two groups as follows:Group A(Test group) and Group B(Control group) with 7 patients in each group. The identification and selection process of subjects meeting the inclusion criteria was approved by the institutional review board. Full case histories and clinical examinations were recorded on standardized forms. Written informed consent was taken from all enrolled subjects before the procedure.

In the test group(Group A), anterior mandibular fractures were treated with Herbert screw of the Stryker company(Figure 1). The diameter of the threads at the leading end was 2.4mm while that on the trailing end was 3.2mm. The shafts had no threads and had a diameter 2.0mm. The length of the screw ranged from 10-40mm.

Fig.1:Herbert Screw of the Striker Company

In the control group(Group B) the patients were treated with two 2mm(4 holes with gap) titanium miniplates that were placed according to the principles of Champy's lines of osteosynthesis and zones of compression and tension.

Pre-operative assessment: The preoperative radiographic assessment was done using digital panoramic radiographs and Cone Beam Computed Tomography (CBCT) to identify the fracture lines, presence of tooth in the line of fracture, degree of displacement and location of the inferior alveolar nerve. The radiograph for each patient was standardized by keeping the exposure time of 12-40 seconds, voltage of 85kVp-90kVp, and current of 10Ma. All the necessary investigations of the patients were done before the procedure. All the patients were treated by open reduction and internal fixation under general or local anesthesia using Herbert screw or miniplates.

Armamentarium

Herbert screw fixation kit included the Herbert screw itself(as shown in figure 1), Cannulated drill machine(Figure 2), 2.0mm Cannulated Drill bit, 3.0mm Cannulated Drill, 1.1mm Guide Wire, T8 Cannulated Stardriver Shaft, Depth Gauze, Canal Cleaning Wire, Drill guide, Quick coupling handle,, Drill Bit with Quick Coupling(Figure 3).

Miniplate fixation kit(Figure. 4) included miniplates(2.0mm plating system-4 hole with gap), monocortical screws, bicortical screws, modelling pliers, handpiece, 1.5mm drill bit, screw holder and screw driver.

Fig.2: Cannulated drill Machine

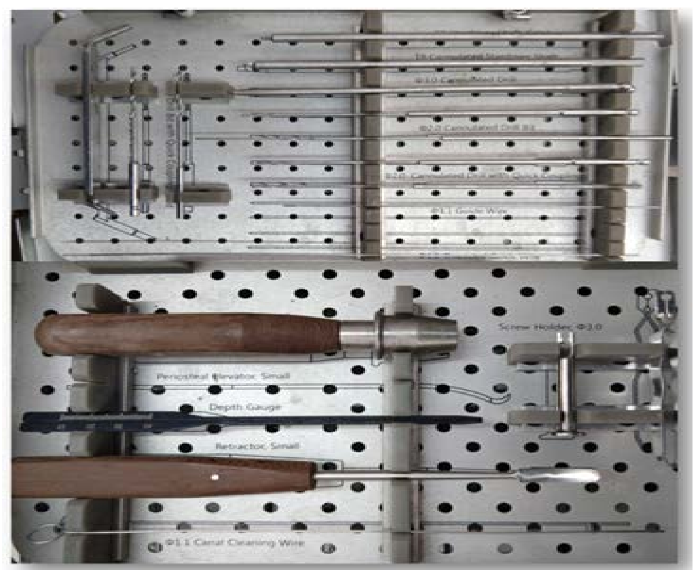

Fig.3: Herbert Screw Fixation Kit

Fig.4: Miniplate fixation kit

Preoperative medications: All patients received one dose of antibiotic (inj. Amoxycillin+ Clavulanic acid 1.2g) preoperatively after test dose.They were also given inj. Dexamethasone 8.0mg preoperatively which was later tapered down for a period of 2 days.

Surgical procedure: Out of total 14 patients, two patients of the miniplate group were operated under local anesthesia while all others were operated under general anesthesia according to the extent of the associated injuries and requirement for their fixation. Patients who were operated under general anesthesia were intubated, painted and draped under aseptic conditions. The fracture sites were either exposed through the intraoral degloving incision or extraorally through the existing laceration. After careful dissection, reduction of the fractured segments was done while maintaining the occlusion intraoperatively by performing intermaxillary fixation which was released after the fixation was done, and the closure was done in layers using 3-0 polyglycolic acid sutures (Vicryl).

Group A: Fixation of the fracture was done using Herbert screw. Preoperative clinical and radiographic assessment of the patients were done (Figure. 5a-d).Preoperative CBCT of each patient in the study was taken.

Fig.5a: Preoperative intraoral photograph showing deranged occlusion due to right parasymphysis and concomitant condylar fracture(Clinical case 1-Group A).b: Preoperative intraoral photograph showing deranged occlusion due to symphysis fracture(Clinical case 2-Group A). c:Preoperative CBCT-scan, coronal cut, showing the fracture line in right parasymphysis region(Clinical case 1-Group A).d: Preoperative CBCT -scan, coronal cut, showing the fracture line in symphysis region (Clinical case 2-Group A).

Under general anesthesia the fracture sites were exposed through intraoral degloving incision or existing laceration (Figure 6a,b).

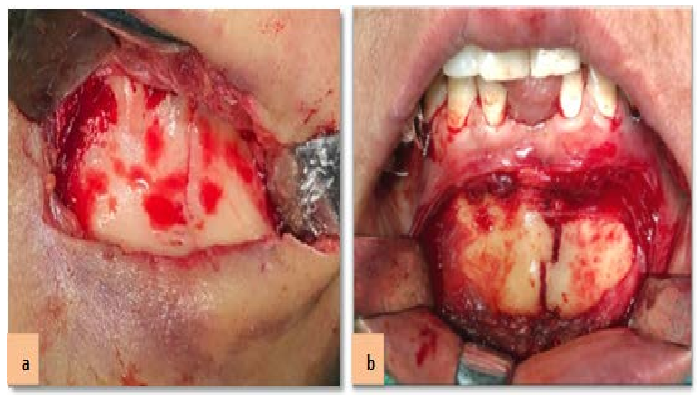

Fig.6a: Fracture site exposed through existing laceration(Clinical case 1-Group A). b:Fracture site exposed through intraoral degloving incision(Clinical case 2-Group A).

A guiding hole with a drill bit of 2mm was drilled carefully in the distal fracture fragment. Hand drilling was commenced with a hollow drill bit while we maintained the coaxility in the distal and proximal fragment using a K wire of diameter 1.1mm(Figure 6c). A depth gauge was used to measure the length of the screw to be inserted(Figure 6d). The headless compression screw was inserted along the K-wire with the help of a cannulated screw driver (Figure 6e).

Fig.6c:Drilling being done while maintaining the coaxility of the fragments using guide wire of 1.1mm diameter(Clinical case 1-Group A).

Fig.6d:Measuring length of the screw using depth gauze(Clinical case 1-Group A). e:Herbert screw being inserted along the K wire using cannulated screw driver(Clinical case 1-Group A).

The screw was inserted into the bone using the compressive sleeve construct in such a way that both the ends got accommodated in the buccal cortical plate for interfragmentary compression (Figure 6f,g).The moment the tip of the compression sleeve made contact with the bone, the fracture gap got closed and compressed. The countersink was performed in order to accommodate the trailing end of the screw after it got inserted.

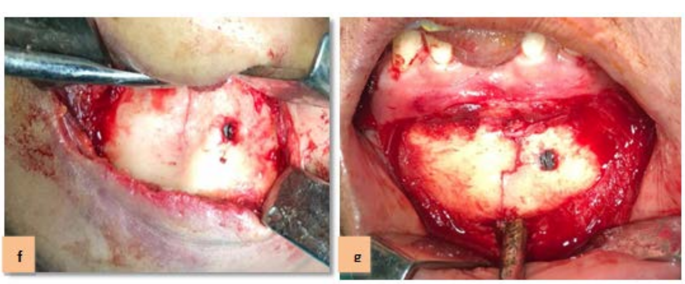

Fig.6f:Both ends of the screw accomodated in the buccal cortical plate for interfragmentary compression(Clinical case 1-Group A).g:Interfragmentary compression achieved using Herbert screw(Clinical case 2-Group A)

The clinical stability of the fracture were checked intraoperatively by performing, labiolingual and supero-inferior movements between the two fracture segments. The arch bars were left in situ for a period of 4 weeks in all patients. Postoperative clinical assessment was done at a period of 2nd, 4th, 6th and 12th week. Radiographic assessment using CBCT was done in all patients after a period of 12 weeks to check for reduction in fracture gap(Figure 7a-d).

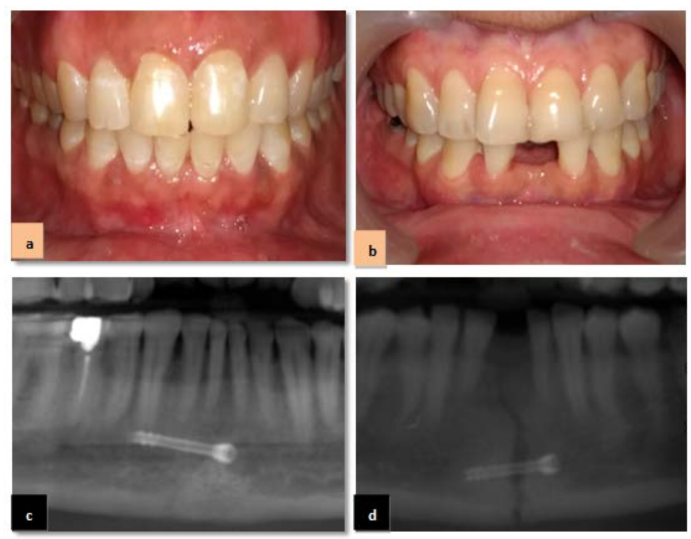

Fig.7a:Intraoral photograph showing satisfactory occlusion at 12th week follow-up(Clinical case 1-Group A).b:.Intraoral photograph showing satifactory occlusion at 12th week follow-up(Clinical case 2-Group A).c:.CBCT-scan, coronal cut, at 12th week follow-up showing complete fracture healing using single Herbert screw(Clinical case 1-Group A).d:CBCT-scan, coronal cut, at 12th week follow-up showing reduced fracture gap after placement of Herbert screw (Clinical case 2-Group A).

Group B: Preoperative clinical and radiographic assessment was done. Fracture site was exposed. After the reduction of the fractured fragments, two miniplates were fixed according to the Champy's principles of miniplates placement. Closure of the wound was done in layers using vicryl suture after adequate hemostasis was achieved. MMF was removed thereafter. The arch bars were left in-situ for 4 weeks. Postoperative clinical and radiographic assessment was done for a period of 12 weeks.

Post-operative medications: All patients were prescribed antibiotics in the form of intravenous Amoxicillin + Clavulanic (1.2g) twice a day for 2 days and then shifted to oral dose of 625mg for 3 days. Analgesic and anti-inflammatory medications were prescribed. Patients were instructed to be on soft diet for one month, and maintain meticulous oral hygiene.

Follow-up: Follow-up was done for a period of 12 weeks. Following parameters were evaluated at 2nd week, 4th week, 6th week and 12th week for all the patients enrolled in the study:

Bite force: Maximum voluntary anterior bite force of the patient was measured by making the patient bite with the upper and lower central incisors. The bite force was measured in kilograms using a bite force transducer (Figure 8). The instrument works on the principle of levers

Pain: It was measured using visual analogue scale (Figure 9). The patients were instructed to draw a vertical line at a point between 0 (no pain) and 10 (unbearable pain).

Occlusion: The occlusion was checked postoperatively for any derangement such as open bite, cross bite, premature contact etc. Any derangement was corrected either by IMF using wires or elastics or by grinding.

Edema: It was evaluated by its ability to pit at the area surrounding the surgical site. The examiner's fingers were pressed into the swelling for 5 seconds. The finger was made to sink into the swelling to leave the impression when it was removed. The pitting was graded on scale of +1 to +4 as follows:+1 (Trace):slight indentation, rapid return to normal, +2 (Mild):4mm indentation, rebound in few seconds, +3 (Moderate):6mm indentation, rebound after 10-20 days and +4 (Severe):8mm indentation and needs more than 30 seconds to return to normal.

Fig.8: Bite force transducer.

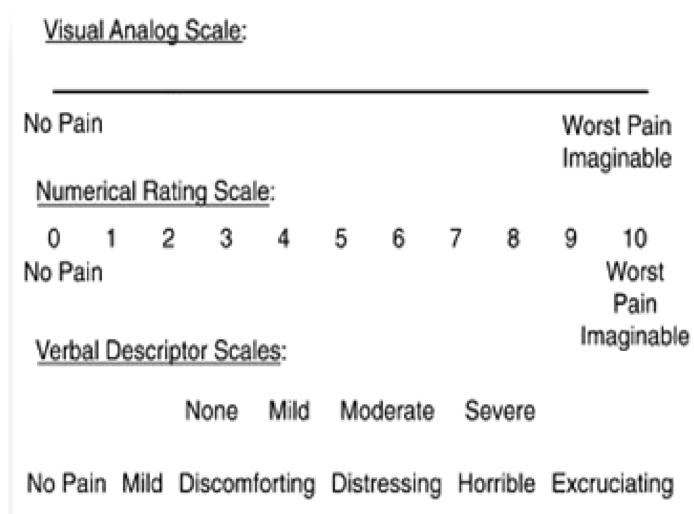

Fig.9:Visual Analogue scale

Nerve function: The patients were asked about any altered sensation of the lower lip. The lower lip on the concerned side was touched with a cotton wisp to check the mental nerve function on that side after making the patient sit and keep the eyes shut.

Stability: It was assessed by checking the interfragmentary mobility by bi-manual palpation across the fracture site

Surgical wound: The wound was examined for any redness, swelling, discharge or dehiscence.

Reduction in fracture fracture gap at 12th week:The fracture gap was measured using CBCT by measuring the distance between the proximal and distal segments at specific reference points. The distance at the 12th week follow-up was substracted from the baseline value to calculate the reduction in fracture gap postoperatively(Figures 10a-d). The fracture healing progression depends on the post-oprative gap. More the gap, less are the chances of healing.

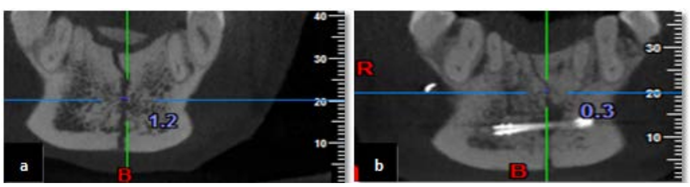

Fig.10 a, b: Fracture gap reduction in Group A(Herbert Screw group) by 12th week, with Fig.10a showing preoperative fracture gap and Fig.10b showing the fracture gap at 12th week follow-up.

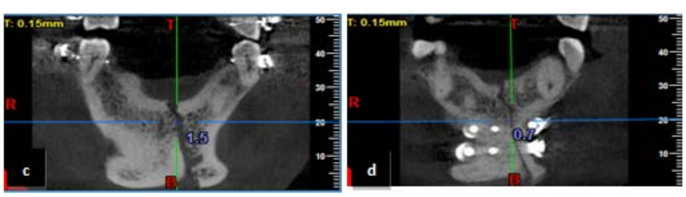

Fig.10c,d:Fracture gap reduction in Group B(Miniplate group) at 12th week, with Fig.10c showing preoperative fracture gap and Fig.10d showing the fracture gap at 12th week follow-up.

Statistical analysis: All the data was entered into the IBM SPSS Software Package version 22. Results on continuous measurements were presented on Mean while those on categorical measurements were presented in numbers(%). Paired sample test, Repeated measure test and pairwise comparison were applied for intragroup comparison. For intergroup comparison, T test, Fisher's exact test and Mann-Whiteney U test were applied. $p \leq 0.05$ was considered significant.

Results

Descriptive data: 14 patients were enrolled in the study, out of which 12 (85.7%) were males and 2 (14.3%) were females. Each group consisted of 7 patients. Patients' age ranged from 19-45 years (Table 1).The most common etiologic factor was road traffic accidents (RTA) (71.4%, n=10), followed by interpersonal violence (14.2%, n=2), sporting injuries (7.14%, n=1) and falls (7.14%, n=1). 1 (7.14%) patient had an isolated anterior mandible fracture, while the remaining 13 (92.8%) had concomitant mandibular fractures. 5 (35.7%) patients had bicondylar fractures, 1 (7.14%) patient had right subcondylar fracture, 3 (21.4%) had left subcondylar fractures, 2 (14.2%) had right angle fracture and 2 (14.25) had left angle fractures.

Clinical data: Anterior bite force: Preoperative and postoperative anterior bite force were measured at the anterior teeth for both the groups with the help of bite force transducer. During the 2nd week, more bite force was observed in the control group (mean=2.050kg/cm^2) as compared to the test group (mean=1.651kg/cm^2). There was no significant improvement in the bite force till 4th week of follow-up in the respective groups ($p \geq 0.05$), but by 6th week it had significantly improved ($p<0.014$) (Fig.11) (Table 2a). The improvement in the bite force in the both the groups from preoperative phase to 12th week follow-up was also significant ($p<0.00$) (Fig.11) (Table 2b). There was no significant difference in the improvement of bite force between both the groups ($p \geq 0.05$) (Fig.11)(Table 2c).

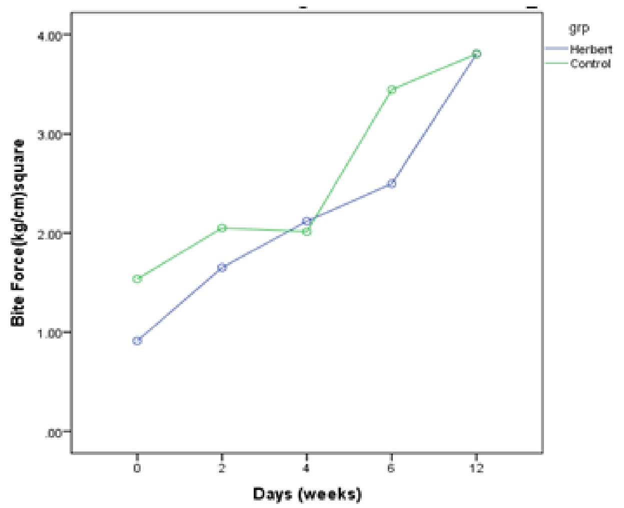

Fig.11:Graph showing the improvement in bite force in both the groups.

Pain: There was a significant decrease in the intensity of pain across the follow-up period in both the groups ($p<0.05$)(Fig.12)(Table 3a). The difference between the two groups according to decrease in the intensity of pain was not significant($p\geq0.05$)(Fig.12)(Table 3b).

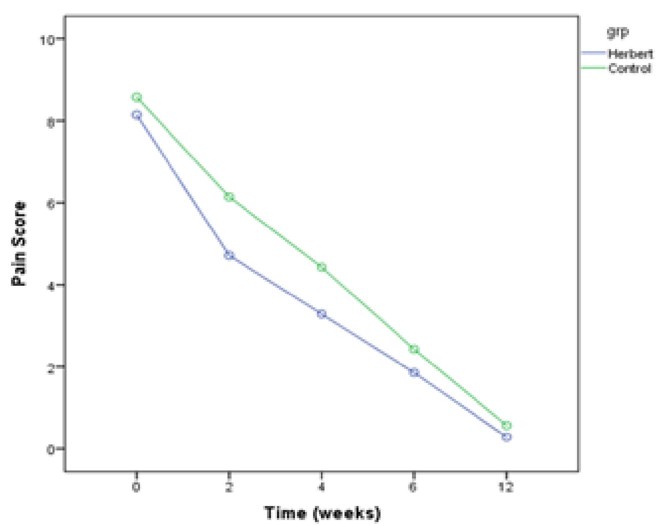

Fig.12:Graph showing reduction in pain intensity in both the groups.

Occlusion: The occlusal examination was done to check for any occlusal discrepancy that could be corrected by means of MMF using elastics or using wires, or by selective grinding. Almost all the 7 cases in the test groups (100%) had deranged occlusion due to injury, while in the control group it was present in 6 (85.7%) cases. During the 2nd week follow-up after open reduction and internal fixation, 2 (28.6%) cases in the test group and 1 (14.3%) case in the control group required the correction of occlusion by means of elastics placement for 2 weeks. By 12th week, the occlusion was found to be intact in all the cases (100%) in the test group whereas 2 (28.6%) cases in the control group required selective grinding to eliminate premature contact. There was no significant difference in the occlusal discrepancy between the two groups.($p\geq0.05$)(Table 4).

Edema: There was no significant difference in the presence of edema between the two groups ($p\geq0.05$). Trace edema was present at the site of injury in the control group at the time of injury in 3 (42.9%) cases. Out of these, 1 (14.3%) case continued to have trace edema at the 2nd week follow-up. No edema was present in any of the cases in the subsequent follow-ups (Table 5).

Paresthesia: Paresthesia of the lower lip was present 1 (14.3%) case in the test group and 2 (28.6%) cases of the control group preoperatively due to the injury. Only one case in the test group continued to have paresthesia in the subsequent follow-ups, which returned to normal by 12th week. In the control group, 6 patients had paresthesia during the subsequent follow-ups, all of them regained normal sensation by the 12th week. Presence of paresthesia in the test group was significantly low as compared to the control group ($p\leq0.05$)(Table 6).

Interfragmentary mobility: Stability was assessed by checking the interfragmentary mobility across the fracture line by doing bimanual palpation. It was present in all the 14 (100%)cases preoperatively as a result of trauma. 4(57.1%) cases in the test group showed slight interfragmentary mobility in the 2nd week , which reduced to only 1 (14.3%)case in 4th and the 6th week follow-up, followed by none (0%) during the 12th week follow-up.

No patient in the control group showed any mobility in any of the follow-up phases. There was no significant difference in the presence of interfragmentary mobility in both the groups (p≥0.05) (Table 7).

Surgical wound: None of the patients showed any signs of infection or wound dehiscence at follow-up (Table 8).

Radiographic data

Reduction in fracture gap at 12 week follow-up There was significant reduction in fracture gap at the 12th week follow-up in both the groups (p≤0.05) (Table 9a). The intergroup comparison did not show any statistical significant difference (p≥0.05) (Table 9b).

Discussion

There is a variety of internal rigid fixation devices available for the management of anterior mandibular fractures, such as wirings, arch bars, resorbable plates, dynamic compression plates, eccentric dynamic compression plates, miniplates, microplates, three-dimensional (3D) plate, locking plates, resorbable plates, lag screws, Herbert screw, etc[15-19]. These devices help in the dissipation of the functional strains, minimize pain, interfragmentary mobility, and also improve occlusion, bite force etc. The technique to be used is chosen on the basis of the preference of the surgeon, clinical signs and symptoms, fracture pattern, financial status of the patient and the availability of the fixation kit of the particular device to be used[20]. There is no sufficient clue regarding the superiority of one technique over the other regarding the postoperative clinical and radiographic outcomes. Though Herbert screw is a minimally invasive technique that requires less surgical time as compared to two miniplates, the latter is more popular because it is less technique sensitive and requires less technical skill. This study was conducted to compare the treatment outcomes of the use of a single Herbert screw with the two miniplates for the internal fixation of the anterior mandibular fractures.The preoperative and postoperative clinical and radiographic evaluation was done for intragroup and intergroup comparison. Follow-up was conducted at 2nd, 4th, 6th and 12th week for the assessment of improvement in anterio bite force using bite force transducer, decrease in pain intensity using visual analogue scale, presence or absence of intact occlusion, edema, paresthesia, interfragmentary mobility and infection or wound dehiscence. Intraoperative reduction in the fracture gap was checked. At the 12th week the fracture healing was assessed by comparing the fracture gap with the baseline using CBCT. Less the fracture gap present postoperatively, better is the healing. The miniplate group showed non-significant decrease in bite force during the 4th week. There was no significant improvement in the bite force till 4th week of follow-up in the respective groups but by 6th week it had significantly improved. Bhatnagar et al had compared stainless steel lag screws with miniplates and found a significant increase in bite force from 2nd to 8th week in both the groups unlike previous studies where there was significant decrease from from 4th and 6th week postoperative week. Bite force can decrease from 4th to 6th week postoperatively because of the return of pain sensations that can take place due to reinnervation of the reflected periosteum after regeneration of the inferior alveolar nerve by this time[21].There was a statistically significant decrease in the intensity of pain across the follow-up period in both the groups, but the intergroup comparison had no significant difference. Bhatnagar et al and Elhussein et al had reported statistically significant decrease in the intensity of pain in both the lag screw and miniplate groups. The mean pain score in these studies was less in the study group as compared to the miniplate group[21,22]. Similarly in our study, the mean pain score in the Herbert screw group was less that that in the miniplate group. The pain at the fracture site had subsided due to adequate stabilization of the fracture segments. The reason for more postoperative pain in the miniplate group is greater quantity of implanted hardware and the amount of bone drilling which is required for the placement of a large number of screws[22]. Kotrashetty et al compared Herbert screw with lag screw and the reported the decrease in postoperative pain to be more rapid in the former , but this difference was not statistically significant[23]. Mahallawy et al conducted a study to check the outcome of Herbert screw fixation in mandibular fractures and found statistically significant decrease in the pain intensity across the follow up period[24].During the 2nd week follow-up 2 (28.6%) cases in the Herbert screw group and 1 (14.3%) case in the miniplate group required the correction of occlusion by means of elastics placement for 2 weeks. By 12th week, the occlusion was found to be intact in all the cases (100%) in the Herbert group whereas 2 (28.6%) cases in the miniplate group required selective grinding to eliminate premature contact. There was no significant difference in the occlusal discrepancy between the two groups. Elhussein et al had reported intact occlusion with no requirement for selective grinding in any patient of the lag screw or miniplate group[22]. Kotrashetty et al reported 26.7% of cases with deranged occlusion in both the Herbert and the lag screw group, which eventually settled in all of the cases. Elastic traction for 15 days was needed in 2 out of 15 patients in the lag screw group to bring the teeth into occlusion[23]. Mahallawy et al, and Ram et al reported satisfactory occlusion in all the cases in their study with the use of Herbert screw[24,26]. In the study by ElMinshawi et al, only one patient requiring spot grinding, and no patient was kept in MMF after the surgery[27]. Mahallawy and Mahalawy did comparison between Herbert screw, lag-screw and 2.0 mm- miniplates for the treatment of anterior mandibular fractures and reported appropriate intercuspal and canine occlusal relations in all of the cases in the three groups. There was no need to do selective extraction, selective grinding or even elastic traction in any case.[28] Lee and Sawhney reported 2.3% of malocclusion with the use of miniplates in the symphyseal region[25].Only one case in the control group in our study had trace edema at the 2nd week follow-up. No edema was present in any of the cases in the subsequent follow-ups. In the study by Elhussein et al, the edema completely resolved in all the cases in the lag screw group while in the miniplate group only one case had trace edema. Thus they reported less duration of post-operative edema in the study group[22]. Agnihotri in 2014 also showed the similar finding with the duration of postoperative edema to be more in the miniplate group when compared to lag screw group[16].One case in the Herbert screw group in our study had paresthesia in the subsequent follow-ups, which returned to normal by 12th week. In the control group, six patients had paresthesia during the subsequent follow-ups, and all of them regained normal sensation by the 12th week. Presence of paresthesia in the test group was significantly low as compared to the control group. Elhussein et al reported temporary sensory impairment in one patient in the lag screw group and two in the miniplate group. All of them regained normal sensation by 12th week[22]. Kotrashetty et al reported abnormal nerve sensation in 26.7% of the patients in the Herbert screw group and 33.3% of the patients in the lag screw group at the first week follow- up. At the 6th week follow-up abnormal nerve sensation was present in 33.3% of the patients in the Herbert screw group, which was higher than that noted at the first week follow-up. By the 12th week follow-up both the groups in their study regained normal nerve sensation. The result did not show any statistical significance. Correlation could be found between the fracture pattern and nerve sensation because most of the patients with abnormal nerve sensation had severely displaced fractures (76.7%) [23,29]. Ram et al reported that three out of the total of seven patients who were treated using second generation Headless Compression Screw for the management of interforaminal mandibular fractures had mental nerve injury which was transient and disappeared on the third week follow-up in one case and after 12th week postoperatively in two cases[26]. ElMinshawi et al reported normal nerve sensations in all the cases treated by Herbert screw[27]. Mahallawy et al reported two out of the total of six patients with fracture anterior to the mental foramen with impaired postoperative lower lip paresthesia at the first week, and by the end of 12th week both the cases regained normal sensation[24]. Mahallawy and Mahallawy reported that the percentage of patients in the Herbert, miniplate and the lag screw group who had altered lip sensation in the lower lip at the first week follow-up was same and all the cases regained normal lip sensation by the end of 12th week[28]. Guemend et al reported fracture manipulation to be the main cause of intraoperative damage to the nerve. Therefore the nerve should be carefully identified and preserved during the surgery and retraction of the soft tissues should be done gently[30].In the Herbert group, 4 (57.1%) cases showed slight interfragmentary mobility in the 2nd week, which reduced to only 1 (14.3%)case in 4th and the 6th week follow-up, followed by none (0%) during the 12th week follow-up. No patient in the control group showed any mobility in any of the follow-up periods. There was no significant difference in terms of presence of interfragmentary mobility in both the groups. In the comparative study done by Kotrashetty et al, inter-fragmentary mobility was found to be present in 20% of the cases in the lag screw group and only 6.7% of the cases in the Herbert screw group during the early follow-up period. There was no statistical difference and the mobility was absent by 6th week. Ardary et al reported the ultimate stability of the fixation of the screw to be dependent on the number of screws used, the method of their placement, bicortical placement of the screws and their holding power, which is influenced by cortical thickening of the bone[31]. This kind of stability occurs due to compression between fragments[32]. Mahallawy and Mahallawy reported only one (14.3%) case in the Lag screw group that had slight mobility at the first postoperative week. No mobility was there in any of the cases in the Herbert or the miniplate group in their study. This intergroup difference was not statistically significant[28].None of the patients showed any signs of infection or wound dehiscence at follow-up visits. Wound dehiscence is less likely to occur with the use of Herbert screw due to its internal positioning, as compared to miniplates. Wound dehiscence usually occurs due to strong mentalis muscle pull, poor suturing technique, contamination, infection, and smoking habits[20]. Elhussein et al reported uneventful wound healing in all the cases with no infection or wound dehiscence[22]. Kotrashetti et al reported two patients in the Herbert screw group to have intraoral wound infection, with no requirement for hardware removal at 8th week. Extraoral wound dehiscence, along with wound infection and the need for hardware removal was found in two cases in the lag screw group[23].

Ram et al reported uneventful wound healing in all the seven patients treated by single second generation Headless Compression Screw. ElMinshawi et al reported no postoperative wound dehiscence in any of the cases[27]. Mahallawy et al reported one case of parasympysis fracture to have wound dehiscence at first week follow–up[24]. Mahallawy and Mahallawy also reported only one case of wound dehiscence in the Herbert screw group at the first week follow-up, while the other two groups i.e.lag screw and miniplate group, and the rest of the patients in the Herbert screw group did not show any signs of infection.[28] All cases of wound dehiscence in these studies were treated by irrigation and wound debridement and allowed to heal by secondary intention.We also checked for the reduction in fracture gap by 12th month follow-up, which was found to be significant in both the groups. The intergroup comparison showed no statistical significant difference in terms of reduction of fracture gap.Unlike bone plates and lag screw placement that can lead to iatrogenic tooth injury if placed blindly, Herbert screw is less likely to cause the same because of the use of K-Guide wire that allows parallel placement of the adjacent screws. This gives an idea of the direction of the screw inside the bone. Out of the three modalities i.e. lag screw, miniplates, and Herbert screw, the former has the highest chances of causing injuries, followed by miniplates and then Herbert screw which has least chances[28]. Use of Herbert screw can be less time consuming as compared to miniplates.Herbert screw is a minimally invasive technique with mimimal postoperative complications, better interfragmentary compression, less chances of injury to the tooth roots, less chances of fracture of the proximal fragment while reduction, less bulky, requires less intraoperative time and has less chances of getting exposed due to internal positioning. It is quite technique sensitive and surgeon dependent. Being a minimally invasive technique it has also been used in angle and condylar fractures[12,33].There was no statistical significant difference between the two groups in terms of improvement in bite force, reduction in the intensity of pain, occlusion, interfragmentary mobility and healing at the fracture site. However, the presence of paresthesia in the Herbert screw group was significantly low as compared to miniplate group. More interfragmentary mobility was found in the Herbert screw group, especially during the second week, but the difference was not statistically significant. There was no edema or any sign of infection or wound dehiscence in any of the groups. The reduction in fracture gap was significant in both the groups, but the intergroup comparison was not significant.

Conclusion

It was concluded that there is no significant difference in the treatment outcomes of both the techniques. Herbert screw is a minimally invasive technique requiring short intraoperative time. Inspite of being less bulky as compared to miniplates, a Herbert screw can result in postoperative results that are equivalent to the use of two miniplates, in terms of improvement in bite force, reduction in pain intensity, occlusion, interfragmentary mobility and healing at the fracture site. Risk of paresthesia is less with the use of Herbert screw. Because of the smaller sample size in our study and less number of studies that have been carried out earlier with the use of Herbert screw, more longitudinal, randomized studies with a larger sample size are required to fill this void.

Acknowledgement: The author would like to thank the entire team of ITS Centre for Dental Studies and

Research, Muradnagar, Ghaziabad for their support in the completion of this study.

Ethics: The study was approved by the Ethical Committee of the I.T.S Centre for Dental Studies & Research, Muradnagar, Ghaziabad, Uttarpradesh, India, and followed the Declaration of Helsinki on medical protocol and ethics.

Patient consent: Written informed consent was obtained.

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Legends Tables

Table 1: Preoperative demographic data

Age, years, mean ±SD	Test group	Control group	*P*-value
	30.57 ± 12.218	33.14± 6.866	0.636
Gender (%)			0.127
Male	71.4% (n=5)	100% (n=7)	
Female	28.6% (n=2)	0.0% (0)	

Table 2a: Intragroup comparison according to improvement in anterior bite force at different phases of follow-up

Test group	Baseline	2nd week	4th week	6th week	12th week
Mean±SD. (n=7)	0.911±0.241	1.651±0.974	2.118±1.642	2.495±1.310	3.807±1.878
P_{pw}	0.064(N.S.)	0.064(N.S.)	0.083(N.S.)	0.014(S.)	0.005(S.)
Control group	Baseline	2nd week	4th week	6th week	12th week
(n=7)Mean±SD.	1.535±0.788	2.050±1.228	2.012±0.815	3.445±1.715	3.807±1.769
P_{pw}	0.357 (N.S.)	0.357 (N.S.)	0.315 (N.S.)	0.014 (S.)	0.659 (N.S.)

Ppw is the p value for pair wise comparison, S.: Statistically significant at p≤0.05, N.S.: Statistically non-significant at p≥0.05

Table 2b: Intragroup comparison according to overall improvement in anterior bite force from baseline to 12th week follow-up

Group	P_{ms}
Test group (n=7)	0.000 (S.)
Control group (n=7)	0.000 (S.)

p_{ms} :p-value for Mauchly's Test of Sphericity for Intragroup comparison

S.: Statistically significant at p≤0.05

Table 2c:Intergroup comparison according to improvement in anterior bite force at different phases of follow-up

Groups	Baseline	2nd week)	4thweek	6thweek	12thweek
Test (n=7) Mean±SD.	0.911±0.241	1.651±0.974	2.118±1.642	2.495±1.310	3.807±1.878
Control (n=7) Mean±SD	1.535±0.788	2.050±1.228	2.012±0.815	3.445±1.715	3.807±1.769
P_t	0.068 (N.S.)	0.514 (N.S.)	0.881 (N.S.)	0.267 (N.S.)	1.000 (N.S.)

P_t is the p-value of T-test for intergroup comparison, N. S. : Statistically non-significant at p≥0.05

Table 3a: Intragroup comparison according to reduction in pain at different phases of follow-up

Test group	Baseline	2nd week	4th week	6th week	12th week
Mean±SD.(n=7)	8.14±1.069	4.71±1.890	3.29±1.604	1.86±1.345	0.29±0.488
P_{pw}	0.005 (S.)	0.005 (S.)	0.001 (S.)	0.000 (S.)	0.000 (S.)
Control group	Baseline	2nd week	4th week	6th week	12th week
(n=7) Mean±SD.	8.57±0.535	6.14±0.900	4.43±1.272	2.43±1.134	0.57±0.535
P_{pw}	0.000 (S.)	0.000 (S.)	0.000 (S.)	0.000 (S.)	0.000 (S.)

P_{pw} is the p value for Pair wise Comparison, S.: Statistically significant at p≤0.05

Table 3b: Intragroup comparison according to overall reduction in pain from baseline to 12th week follow-up

Group	P_g
Test group (n=7)	0.000 (S.)
Control group (n=7)	0.000 (S.)

P_g :p-value for Greenhouse-Geisser test for intra group comparison, S.: Statistically significant at p≤0.05

Table 3c: Intergroup comparison according to reduction in pain at different phases of follow-up

Groups	Baseline	2nd week	4th week	6th week	12th week
Test (n=7) Mean±SD.	8.14±1.069	4.71±1.890	3.29±1.604	1.86±1.345	0.29±0.488
Control (n=7) (Mean±SD.)	8.57±0.535	6.14±0.900	4.43±1.272	2.43±1.134	0.57±0.535
P_t	0.361 (N.S.)	0.096 (N.S.)	0.165 (N.S.)	0.407 (N.S.)	0.317 (N.S.)

P_t :p-value for T-test for comparing between the two groups, N.S.: Statistically non-significant at p≥0.05

Table 4: Intergroup comparison according to occlusion

Group	Baseline Present Absent	2nd week Present Absent	4th week Present Absent	6th week Present Absent	12th week Present Absent
Test (n=7)	0.0% 100.0% (n=0) (n=7)	71.4% 28.6% (n=5) (n=2)	100% 100% (n=7) (n=7)	100.0% 0.0% (n=7) (n=0)	100.0% 0.0% (n=7) (n=0)
Control (n=7)	14.3% 85.7% (n=1) (n=6)	85.7% 14.3% (n=6) (n=1)	100% 100% (n=7) (n=7)	71.4% 28.6% (n=5) (n=2)	71.4% 28.6% (n=5) (n=2)
p_f	1.000 (N.S.)	1.000 (N.S.)	_	0.462 (N.S.)	0.462 (N.S.)

p_f is the p value for Fisher's exact test for intergroup comparison, N.S.: Statistically non-significant at p≥0.05

Table 5: Intergroup comparison according to edema

Group	Baseline Present Absent	2nd week Present Absent	4th week Present Absent	6th week Present Absent	12th week Present Absent
Test (n=7)	0.0% 100.0% (n=0) (n=7)	0.0% 100.0% (n=0) (n=7)	100% 100% (n=7) (n=7)	100.0% 0.0% (n=7) (n=0)	100.0% 0.0% (n=7) (n=0)
Control (n=7)	42.9%% 57.1% (n=3) (n=4)	14.3% 85.7% (n=1) (n=6)	100% 100% (n=7) (n=7)	100.0% 0.0% (n=7) (n=0)	100.0% 0.0% (n=7) (n=0)
p_f	0.192(N.S.)	1.000 (N.S.)	_	_	_

pf is the p value for Fisher's exact test for intergroup comparison N.S.: Statistically non-significant at $p \geq 0.05$

Table 6: Intergroup comparison according to paresthesia

Group	Baseline Present Absent	2nd week Present Absent	4th week Present Absent	6th week Present Absent	12th week Present Absent
Test (n=7)	14.3% 85.7% (n=1) (n=6)	14.3% 85.7% (n=1) (n=6)	14.3% 85.7% (n=1) (n=6)	14.3% 85.7% (n=1) (n=6)	0.0% 100.0% (n=0) (n=7)
Control (n=7)	28.6% 71.4% (n=2) (n=5)	85.7% 14.3% (n=6) (n=1)	85.7% 14.3% (n=6) (n=1)	71.4% 28.6% (n=5) (n=2)	0.0% 100.0% (n=0) (n=7)
p_f	1.00 (N.S.)	0.005 (S)	0.005 (S)	0.005 (S)	_

pf is the p value for Fisher's exact test for intergroup comparison, S.: Statistically significant at $p \leq 0.05$, N.S.: Statistically non-significant at $p \geq 0.05$

Table 7: Intergroup comparison according to interfragmentary mobility

Group	Baseline Present Absent	2nd week Present Absent	4th week Present Absent	6th week Present Absent	12th week Present Absent
Test (n=7)	100.0% 0.0% (n=7) (n=0)	57.1% 42.9% (n=4) (n=3)	14.3% 85.7% (n=1) (n=6)	14.3% 85.7% (n=1) (n=6)	0.0% 100.0% (n=0) (n=7)
Control (n=7)	100.0% 0.0% (n=7) (n=0)	0.0% 100.0% (n=0) (n=7)	0.0% 100.0% (n=0) (n=7)	0.0% 100% (n=0) (n=7)	0.0% 100.0% (n=0) (n=7)
p_f	_	0.07 (S)	1.00 (N.S.)	1.00 (N.S.)	_

p_f is the p value for Fisher's exact test for intergroup comparison, S.: Statistically significant at $p \leq 0.05$, N.S.: Statistically non-significant at $p \geq 0.05$

Table 8: Intergroup comparison according to surgical wound

Group	2nd week Present Absent	4th week Present Absent	6th week Present Absent	12th week Present Absent
Test (n=7)	0.0% (n=0) 100.0% (n=7)	0.0% (n=0) 100.0% (n=7)	0.0% (n=0) 100.0% (n=7)	0.0% (n=0) 100.0% (n=7)
Control (n=7)	0.0% (n=0) 100.0% (n=7)	0.0% (n=0) 100.0% (n=7)	0.0% (n=0) 100.0% (n=7)	0.0% (n=0) 100.0% (n=7)
p_f	–	–	–	–

P_f is the p value for Fisher's exact test for intergroup comparison, No stats are computed because surgical wound is a constant.

Table 9a: Intragroup comparison according to reduction in fracture gap by 12th week follow-up

Group	Test group (n=7)			Control group (n=7)		
	Baseline	Post-reduction	Fracture gap reduction by 12th week	Baseline	Post-reduction	Fracture gap reduction by 12th week
Fracture gap (Mean±SD.)	1.63±1.01	0.442±0.377	1.185±0.922	1.571±0.958	0.385±0.333	1.185±1.106
P_p			0.014 (S.)			0.030 (S.)

P_p: p value for paired sample test, S.: Statistically significant at $p \leq 0.05$

Table 9b: Intergroup comparison according to reduction in fracture gap by 12th week

Group	Baseline	Postreduction	Reduction by 12th week
Test (n=7)	1.62±1.01	0.44±0.72	1.185±0.922
Control (n=7)	1.57±0.96	0.39±0.33	1.185±1.106
p_{mw}	0.95(N.S.)	0.74(N.S.)	0.70(N.S.)

p_{mw} is the p value for Mann-Whiteney U test for intergroup comparison, N.S.: Statistically non-significant at $p \geq 0.05$