The Tension Wire Method

A Simple, Effective Means of Mandibular Fixation

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Objective: To investigate the use of a tension wire band secured to monocortical screws for open reduction and internal fixation of simple, displaced, and/or unstable mandibular fractures.

Design: Retrospective review with follow-up duration of at least 6 weeks.

Setting: Level I university trauma center.

Patients: Twenty-nine patients (27 males and 2 females), aged 7 to 46 years. Ten patients had unilateral fractures (1 patient had 3 separate unilateral fractures) and 19 had bilateral fractures; 34 of 50 fractures were displaced; 19 were open intraorally. The location of fractures and the number (number repaired) were as follows: symphysis or parasymphysis, 13 (10); body, 9 (8); angle, 18 (14); ramus, 6 (4); and subcondylar, 4 (0). Two fractures were each comminuted into 3 fragments, and 1 patient had unilateral parasymphysial, body, and ramus fractures.

Intervention: Intermaxillary fixation was done in all patients except 1 child. Intraoral approaches were used exclusively. A pair of monocortical 2.0-mm screws were placed perpendicular to fracture lines, with 24-gauge wire loops passed around the screws and tightened to bring the fracture into reduction and provide stable fixation. A percutaneous trocar system was used to insert screws at the body, angle, and ramus sites.

Results: There were no instances of infection, malunion, or malocclusion in the 33 fractures repaired with this technique. A typical intermaxillary fixation with open reduction and internal fixation of a posterior fracture was done in less than 2 hours.

Conclusion: Open reduction and internal fixation of simple mandibular fractures with tension wire bands around monocortical screws is a simple, quick, and effective technique.


MANDIBLE fractures are a common facial injury, and the repair of these fractures has evolved with the introduction of rigid internal fixation by means of plates and lag screws. Although a plating system was described as early as 1886, the high complication rate made intermaxillary fixation (IMF) the prevailing treatment for mandible fractures until the 1970s, when numerous systems began to emerge.

In 1972, Spiesseler advocated an alveolar tension band technique that used a monocortical plate, combined with bicortical inferior dynamic compression plates first described by Allgower et al. In 1978, Champy et al introduced a noncompression system that used an intraoral approach with monocortical screws and malleable miniplates, modifying Michele's and coworkers' midface and mandible fracture repair technique. In 1981, Niederfellmann et al reported a lag screw technique for mandible angle fracture repair, and Ellis and Ghali described the use of lag screws for anterior mandibular fracture fixation in 1991. Two other systems that have been used are the external pin fixation system and a memory clamp.

Investigation during the past decade has compared traditional interosseous wiring, compression plating, lag screw, and miniimplating with and without IMF for internal fixation. The current literature offers many positions, from support for IMF with interosseous wiring or compression plates or miniplates, to nonsupport for miniplates. There are also reports of no difference between current methods with recommendations of further testing. Criticisms of rigid plating fixation include increased complications, duration of procedure, and cost.

The tension wire method (TWM) discussed in this report is a procedure that uses monocortical screws with stainless-steel wire for fracture reduction and fixation in conjunction with intermaxillary fixation. It is similar in concept to tension band techniques used for fixation of olecranon and patellar fractures in orthopedic surgery.
PATIENTS AND METHODS

PATIENTS

Medical records of 29 patients (27 males and 2 females) with mandible fractures were retrospectively reviewed, from September 1993 to January 1997. Adults were considered to be patients who were 16 to 46 years old; there were 2 children, aged 7 and 12 years. Mean age was 23 years. The method of injury was compatible with those in other reports, with the majority of those injured being young men involved in assaults (17 patients) and motor vehicle accidents (9 patients), with 1 incident each caused by an oil drilling rig accident, a trampoline injury, and a fall.

A total of 50 fractures were present, with 33 being fixed by the TWM, 1 angle fracture by TWM and miniplate, 1 body fracture by lag screw, and 1 parasymphyseal fracture by circumdental wiring. Ten patients had fractures that were unilateral (1 patient had 3 separate unilateral fractures; see below) and 19 had bilateral fractures; 34 of 30 fractures were displaced; 19 were open intraorally. The location of fractures and the number (number repaired) were as follows: symphysis or parasympysis, 13 (10); body, 9 (8); angle, 18 (14); ramus, 6 (4); and subcondylar, 4 (0). One ramus and 1 angle fracture were each comminuted into 3 fragments, and 1 patient had 3 unilateral fractures, at the parasympysis, body, and ramus. The remaining patients had simple, solitary fractures on the side(s) involved. The IMF was performed on all patients except a 7-year-old boy with loose deciduous teeth and missing dentition. Of the 20 patients with multiple fractures, 14 had 1 minimally displaced, stable fracture for which closed treatment with IMF was sufficient. Preoperative antibiotics consisting of metronidazole hydrochloride and a first-generation cephalosporin were administered intravenously and continued for 1 day. Patients were discharged on the first postoperative day unless discharge was precluded by other injuries. Only cases with at least 1 fracture site that received the TWM as the sole method of internal fixation were reviewed. In addition, all patients must have returned for a minimum of 6 weeks of follow-up after surgery.

SURGICAL TECHNIQUE

All procedures were performed by one of us (R.C.W.). Arch bars were first placed, and IMF was performed except in some angle and ramus fractures in which exposure to the superior aspect of the fracture was better without IMF. All fractures were approached through intraoral incisions. The mental nerve was exposed and protected during anterior exposure. Screw holes for 2.0-mm-diameter self-tapping titanium or stainless-steel screws, 4 or 6 mm in length, were placed perpendicular to and on each side of the fracture line, and preferably where there was a “tongue in groove” alignment (third molar tooth socket edges are also useful for alignment of angle fractures). A 1.5-mm drill with a 6-mm stop was used for placement of monocortical screws, and they were placed approximately 4 to 6 mm from the

RESULTS

No cases of malocclusion, malunion, nonunion, or infection occurred. No excessive distraction of the lingual fractures was demonstrated by postoperative computed tomographic results. All posterior body, angle, and ramus fractures were able to be reduced and internally fixated without the use of external incisions. Early in the series, 2 sets of tension wires and screws became exposed after bony healing and were removed with the patient under local anesthesia without underlying infection. The use of circumdental wiring and the placement of hardware lower on the mandible away from the alveolus prevented recurrence of this problem. The 7-year-old patient with bilateral unstable fractures (right parasympysis and left body) had stable fixation with 2 tension wires on each fracture without IMF, and his fractures healed uneventfully with a nonchewing diet for 4 weeks.

Preoperatively, 19 of the 29 patients had hypesthesia of the mental nerve distribution—5 patients had improved but residual hypesthesia after 6 weeks, with the remaining 14 having normal sensation. The mental nerve was preserved in every case. Not every fracture could be reduced securely with this technique; in 2 cases with unfavorable displaced fractures of the body and angle ramus, the fracture planes allowed the TWM forces to pull the fragments away from ideal reduction. A lag screw was used in the body fracture and a miniplate with TWM in the angle ramus fracture. Since multisystem injuries occurred with both motor vehicle accidents and assaults, the calculation of the number of hospital days included only those patients with isolated mandible injury. The combined preoperative and postoperative hospital days had a range of 2 to 4 days, with an average of 2.4 days.

COMMENT

The goals of mandible fracture repair are to obtain good dental occlusion, achieve bony union, preserve mental and facial nerve function, prevent posttraumatic sequelae such as osteomyelitis, and attain optimal cosmesis by retaining teeth and minimizing external scars. While IMF alone for favorable fractures can fulfill these criteria, open reduction and fixation must be considered for displaced and unstable fractures. Rigid plate and lag screw fixation have the advantage of allowing mastication without the 4 to 6 weeks of IMF required by interosseous wire fixation. Reported complication rates for current plating procedures range from 3.6% to 21.3% for infection; from 0.5% to 1.9% for malunion; 0.3% for delayed union; 2.6% for facial nerve damage; and 1.4% to 3.7% for mental nerve damage. Increased complexity, cost, and complications are associated with plating. The exposure necessary for plate insertion further devascularizes bony fragments. Bicortical plating has a risk of injury to the inferior alveolar neurovascular bundle, as does lag screw use. Plating at the posterior body, angle, and ramus can be technically challenging for unstable, displaced fractures, and often requires exposure through an external incision for adequate reduction and fixation. Rigid fixation of posterior unstable, dis-
fracture line. These screws were tightened down and then reversed 2 turns to allow a 24-gauge stainless-steel wire loop to be passed around them and fit underneath the head of the screw. The wire loop was tightened onto rather than between the screws, producing both reduction and fixation. The screws were then tightened, resulting in further reduction because of the conical shape of the screw head, and the stability and reduction of the fracture was checked. The incision was closed by means of simple, interrupted sutures of 3-0 chromic catgut on a tapered needle.

It is important to place the screws on a smooth, flat or convex surface so that the wire loop exerting the tension forces lies in contact with the fracture line, minimizing the moment arm of torque at the corners of the fracture beneath the wire to essentially one-half the diameter of the wire, so that lingual separation of the fractures does not occur (Figure 1). This was demonstrated by means of 2 fixed cadaver mandible specimens, from 1 man and 1 woman. Saw cuts perpendicular to the buccal cortex were made at both angles and at the symphysial of each mandible, for a total of 6 cuts. Placing the screws and wire loops on the buccal surface so that the wires contacted the bony cortices at the cut/fracture line did not result in lingual cortical distraction when the wire loops were tightened to reduce and fixate the buccal cortex fragments. Although the lingual cut edges were easily forced opened in this cadaver model after TWM fixation, this fixation is resistant to lingual manipulation in patients, probably because of additional soft-tissue forces on the mandible in situ.

Incorrect placement of the screws and wire loop such that the screws are on a concave surface surrounding the fracture line, resulting in the wire loop being lifted away from the bony surface at the fracture line, will cause lingual distraction because of increased torque. Muscles and other soft tissues inserting on the lingual mandible cannot be expected to prevent lingual distraction as the wire loop is tightened under these circumstances.

Circumden tal wiring and TWM placed at the superior or inferior surface are recommended to produce torque forces that help reduce the lingual portion of the fracture and provide multiplanar fixation. For parasymphysial and body fractures with good dentition, 1 set each of 2 screws and wire can be placed at the midportion and inferiorly, along with circumdental wiring when possible for reduction superiorly (Figure 2 through Figure 5). For other fractures, 2 or 3 sets of screws are usually necessary, reducing and fixating the fracture in different planes. Third molar teeth are extracted when displaced angle fractures pass through their roots, to reduce infection and increase exposure. Angle and ramus fractures can be reduced in 2 planes: along the superolateral border transorally, and laterally toward the inferior border transcutaneously by means of a percutaneous trocar system (Figure 6 and Figure 7). For the lateral surface of posterior fractures, the surgeon holds and directs the trocar system and views the fracture transorally, while the assistant drills and places the screws. The surgeon then passes and tightens the wire loop around the screws transorally to reduce and fixate the fracture. The reduction is checked within 1 day postoperatively with a mandibular panoramic radiograph routinely and with computed tomography when deemed necessary to examine for reduction in badly displaced and unstable fractures.

Interosseous wiring is simple and inexpensive and needs less exposure than rigid fixation techniques. It can reduce and fixate the fracture but is nonrigid, and tends to loosen because of the pressure of the thin wire on the comparatively soft cortical bone. Threading the wire through both fragments can be difficult and must be repeated if the wire is broken during tightening. External incisions are often necessary for approaches to the inferior and posterior aspects of the mandible.

The TWM is simple, requires little exposure, and is relatively inexpensive (the cost of 2 TWM bands to the hospital consists of four 2.0-mm screws, 1 drill, and wire, or

**Figure 1.** Drawing showing the tension wire method, with O indicating axis of rotation; F, force exerted by wire loop; R, moment arm from O perpendicular to F vector; and M, lingual muscular forces on lingual cortex.

**Figure 2.** Symphysial fracture fixation with the use of the tension wire method (cadaver specimen).
Two–lag screw fixation, 2 miniplates, and single dynamic compression plate fixation of symphysial fractures would cost $285, $559, and $530 in hardware, respectively. The extra time for miniplates and application of a dynamic compression plate is about 45 minutes, and 20 to 30 minutes for lag screw fixation, in our experience. For angle fractures, the cost for the TWM is $152 plus wire; for dynamic compression plate and tension band plate, $839 plus an additional hour of surgery; and for 2 superior border tension miniplates, $559 plus 45 minutes to an hour more time.
The TWM is easy to perform, requires less dissection and exposure than that for plating or lag screw use, and is applicable to most simple fractures of the parasymphysis, body, angle, and ramus without the need for external incisions. For anterior fractures, an IMF and TWM fixation can be done in as little as 1 hour 15 minutes. Posterior displaced, unstable fractures can be repaired with IMF and TWM by means of transcutaneous screw insertion in 2 hours. Provided a safe distance is left between the fracture edge and the drill hole, the wire will break before the screw avulses with tightening; another wire loop is easily reapplied. This method reduces and fixation the fracture simultaneously; it can also be used to reduce an unstable fracture for or in combination with lag screw or plate application. No distraction of the fracture edges is necessary, as is sometimes the case with interosseous wiring. Although as rigid as lag screw or plate fixation, TWM is quite strong when 2 or more planes of fixation can be achieved. Another screw and wire loop can be added to adjust reduction. The TWM can theoretically allow lingual fracture distraction, as could happen with plate application if insufficient “overbending” is performed when the plate is contoured. However, when the principles discussed in the “Surgical Technique” section are adhered to to negate unwanted torque, results from experiments on cadaver mandibles and this series of patients show that multiaxial TWM achieves stable reduction without lingual fracture displacement. Just as tension band repair of elbow and patellar fractures is performed successfully without inner cortex fixation because of muscular forces enhancing inner cortex compression,23 soft-tissue forces acting on the mandible after buccal cortical reduction and fixation with the TWM seem to resist lingual distraction, as the fractures in this clinical series were difficult to manipulate after TWM was achieved (vs in the cadaver models with no soft-tissue attachments, in which lingual manipulation was easily performed), with postoperative computed tomographic scans also confirming lingual reduction in clinical cases. Nevertheless, these soft-tissue forces cannot be expected to prevent the lingual separation that would occur if the TWM were incorrectly applied, producing substantial unwanted torque. That the majority of the muscles to the mandible (medial and lateral pterygoids, mylohyoid, anterior belly of digastric, and geniohyoid) exert pull toward the center of the arc of the mandible may reinforce lingual reduction once optimal buccal and superior cortical reduction and fixation are achieved.

The titanium screw and stainless-steel wire combination used in this series has a theoretical problem of galvanic current flow and long-term corrosion. One patient with a TWM placed had a mandibular panoramic radiograph performed 3 years subsequently because of contralateral mandibular fracture, which did not show any changes in wire loop configuration or size. Stainless-steel screws are available in the sizes recommended and can be used instead of titanium screws to address this issue.

A major disadvantage of the TWM is the use of IMF, which precludes immediate oral rehabilitation, as is possible with plate and lag screw rigid fixations.

The TWM is an attractive alternative to current methods of mandibular internal reduction and fixation for simple displaced and/or unstable fractures, with no increased complication rates, low cost, and comparative ease of use. It is particularly versatile for posterior fractures approached transorally without external skin incisions. Generally supplemented by IMF, it should not be used where IMF is contraindicated, such as in the elderly, debilitated patients, and those with increased nutritional demands, for whom early oral rehabilitation is important. Fracture selection is important, as this technique is best applied to simple fractures perpendicular to the cortices, or with interlocking fracture surfaces. The TWM is not usually applicable as the sole method to repair comminuted fractures, nor should it be used for oblique unstable fractures in which the TWM would tend to further distract the fragments. These latter fracture types are best repaired with lag screw and/or plating techniques.

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REFERENCES


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