Safety and Efficacy of Anterior Odontoid Screw for the Management of Odontoid Fractures. A Series of 22 Patients.

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Fractures. A Series of 22 Patients

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Abstract

Background Data: Several methods of treatment of odontoid fractures have been used. These have ranged from rigid immobilization to atlantoaxial fusion. Odontoid screw osteosynthesis is gaining popularity**.**

Purpose: To define the efficacy and safety of odontoid screw fixation in the management of odontoid fractures and to report the clinical and radiological results.

Study Design: A prospective cohort study of odontoid fractures treated with odontoid screw osteosynthesis. The study was conducted in Cairo university hospital, Egypt and AOA Neuro-spinal Centre, Libya in the period from January 2007 to October 2010.

Patients and Methods: Over the period from January 2007 to October 2010, twenty two patients, 17 males and 5 females, with a mean age of 32.5 years were included in this study. These were 19 odontoid type-II and 3 shallow type-III fractures**.** All patients underwent odontoid screw fixation using a single screw.

Results: Mean operative time was 80 minutes and mean blood loss 150 ml Patients were followed for a mean period of 20.6 months. Nineteen patients (87%) obtained a good or excellent result on the Smiley Webster scale. Fourteen patients (64%) obtained a bony union, 7 (32%) a stable fibrous union and one patient (4%) developed a pseudoarthrosis. One patient had a misplaced screw that was successfully revised and another patient had displacement of the screw with re-displacement of the fracture at three months follow up. He had removal of the screw and underwent atlanto-axial fusion.

Conclusion: This study has proven the efficacy and safety of odontoid screw osteosynthesis in selected types of odontoid type II and shallow type III fractures. (2012ESJ024)

Keywords: Odontoid fracture, upper cervical spine, odontoid screw fixation, anterior odontoid fixation, osteosynthesis of odontoid.

Introduction

Fractures of the odontoid account for 18-20% of all cervical spine fractures[11]. In younger patients, these fractures tend to occur as a result of high energy trauma such as motor vehicle accidents, while in older patients, they tend to result from low energy injuries as simple falls[12]. Anderson and D'Alonzo described a classification that is the most widely used based on the anatomical site of fracture in the odontoid: Type-I fractures involve the tip of the odontoid, type-II involves the waist and type-III includes fractures involving the body of the axis[3].

A more recent classification was introduced in a modification for the previous (Anderson and D'Alonzo) classification. It offers a clearer distinction between type-II and type-III dens fractures: Type-II fractures are those that occur below the inferior aspect of the anterior C1 ring and do not extend into the C1–C2 facets. Type-II fractures are further divided into 3 subtypes. The 3 subtypes are labeled A, B, and C[17].

The optimal treatment of odontoid fractures is controversial. Traditionally, non-rigid immobilization, halo orthosis, traction and posterior CI-2 arthrodesis have been used to treat these fractures, with varying degrees of success[7,21,24,31]. Recently, anterior odontoid screw fixation has gained popularity for the treatment of Type II odontoid fractures[1,5,8,18].

Evidence-based analysis of the current literature on the management of odontoid fractures demonstrates the limitations in providing guidance to spine surgeons in terms of the best treatment available for such a fairly common injury[27,28]. Therefore we conducted this study to further define the safety, efficacy and complications of Odontoid screw fixation as a modality for management of Odontoid fractures.

Patients and Methods

Over the period from January 2007 to October 2010, twenty-two patients ranging in age from 23 to 42 years are included in this prospective study. Patient demographics are shown in table 1. Preoperative assessment included thorough clinical and neurological examination. All patients were neurologically intact (ASIA E). The mechanism of injury is shown in table 2. Radiological study included plain x-rays (antero-posterior (AP), lateral and open mouth views), CT for upper cervical spine with sagittal reconstruction and MRI.

Table 1.
Patients Demographics.

Characteristic	**Number of Cases**
(Sex (male/female	17/5
Age (mean) years	(32.5)23-42
Range of follow up (mean) months	(23.2)12-48
(Period of injury to operation (days	3-25

Table 2.
Mechanism of Injury.

Mechanism of injury	**Number of Cases**
Motor vehicle accident	12
Diving injury	6
Fall	4

Fractures were classified according to the Anderson-D'Alonzo classification, and sub classified according to Grauer et al.[17] There were 19 type-II fractures and 3 shallow type-III (Table 3). All operations were done by either authors of the study in 2 spine centers: Cairo university hospital, Egypt and AOA Neuro-spinal centre, Libya.

Table 3.
Fracture Classification.

Type of fracture	Number of Cases
II A	2
II B	11
II C	6
III	3

Single cannulated screw fixation in all cases was carried out using biplanar fluoroscopy using one image intensifier in 10 cases and two image intensifiers in 12 cases. All patients were mobilized postoperatively and instructed to use a Philadelphia neck collar for 8 to 12 weeks.

Operative Technique:

After general anaesthesia with endotracheal intubation, the patient is placed supine on the operating table. The endotracheal tube is kept on the right side as we use a left sided approach. A Mayfield frame is used to hold the head immobile. The patient's mouth is kept open with a radiolucent jaw block. Fluoroscopy machines are then positioned to obtain clear open mouth AP and lateral views of the odontoid (Figure 1). Manipulation of the Mayfield frame is performed under fluoroscopy control to obtain an anatomical reduction of the odontoid fracture. Once that is achieved, the frame is tightened securely. A long K wire is used to rehearse the position of the guide wire and trajectory of access to the odontoid. This rehearsal is a vital step to make sure that the patient's chest is not too high to block a proper access and alignment of the odontoid screw.

Figure 1.
The layout of the operating room; 2 image intensifiers positioned and fixed with the patient's head fixed with a Mayfield frame.

The patient's neck is then prepped and draped in a sterile fashion. A left sided horizontal incision is made at approximately the level of C4-5 disk. The platysma is then elevated and divided; and the fascia of the sternocleidomastoid is sharply incised along its medial border. Blunt dissection is used to expose the anterior surface of the spinal column at the mid-cervical level by opening natural planes medial to the carotid artery sheath and lateral to the trachea and esophagus.

The fascia of the longus colli muscle is incised in the midline, and the muscle is elevated for a few millimeters off the vertebral bodies at the C4–5 level. Sharp, toothed Cloward retractor blades are then inserted beneath the longus colli bilaterally and secured. Blunt dissection in the retropharyngeal space is used to open a tunnel in front of the spine to the C2 level for accessing the lower anterior border of C2.

An angled retractor of the appropriate size is inserted into this space and coupled to the lateral retractors. A sharp starter is used to create a hole in the anterior inferior angle of C-2 body. A K-wire is inserted through the incision up to the inferior edge of C-2, under fluoroscopic control, and impacted into the inferior edge of C-2. As we always use a single screw, a midline entry site is chosen.

A guide tube is placed over the K-wire and rotated by hand to the inferior border of C-2. Once the guide tube is secured, the K-wire is advanced from the inferior anterior edge of C-2 through the body of C-2 and into the odontoid to its apex passing through the fracture while using careful biplane fluoroscopic control. Then a cannulated drill bit is inserted over the K-wire. A right-angle drive is used to clear the thoracic region, and a hole is then drilled while using careful biplane fluoroscopic control from the inferior anterior edge of C-2 through the body of C-2 and into the odontoid to its apex. The drill is calibrated to allow accurate depth measurement. The drilled hole is then tapped (threaded) by removing the drill bit, replacing it with the cannulated tap that is manipulated by hand while monitoring its progress fluoroscopically.

The selected screw, based on the measured depth, is placed over the guide wire into the drilled and tapped hole. We used lag screws with a non-threaded proximal shaft in 19 cases and fully threaded screws in 3 cases. The screw is placed into the odontoid and tightened firmly, as progress is monitored fluoroscopically. The head of the screw is recessed into the C2–3 annulus/disc edge or into the inferior edge of C-2, and the screw tip is fully engaged into the apical cortex of the odontoid. The retractors are then removed, the wound checked for hemostasis, and closure completed in layers. Philadelphia neck collar is applied to the patient's neck before extubation.

Results

Twenty two patients (100%) underwent single anterior odontoid screw fixation for the treatment of odontoid fractures. All patients recovered well from surgery and remained neurologically intact (ASIA E). Mean operative time was 80 minutes (range 65-120). Mean blood loss was 150mls (range 100-300mls). Mean hospital stay was 5.5 days (range 3-9days). Patients were followed for a mean period of 20.6 months (range 12-28 months).

We used the Smiley-Webster scale[33] to assess the overall functional outcome of our patients (Table 4). Twelve patients (55%) were rated excellent, seven (32%) rated good, two (9%) rated fair and one (4%) rated poor. This single poor result was a patient that had screw cut through with redisplacement of the fracture and underwent revision removal of the screw and atlanto-axial fusion.

Table 4. Smiley–Webster Scale Used to Assess Functional Results[33].

Scale	Description
I:Excellent	Patient returned to full-time work/activity as before onset of symptoms; no pain medication required
II: Good	Patient returned to full-time work/activity; occasional consumption of pain medication
III: Fair	Patient not able to return to former level of work/activity; occasionally pain medication; improved over preoperative
IV: Poor	Patient not able to return to work/former activity *level*; regular consumption of pain medication

Figure 2. WG, 27 year old male sustained an Odontoid type IIB. 12 months post x-ray showing bony healing, confirmed by a CT scan.

Radiological assessment included plain x-rays, dynamic films and CT scan. Figure 2, demonstrates one of our patients with sound bone fusion. Table 5 shows the radiological criteria and healing status in this series.

Table 5. Fracture Healing Status.

Fracture healing	Criteria	No. of patients (%)
Bony union	Bridging bony trabeculae across fracture, no movement on dynamic films and no implant failure.	14 (64%)
Stable fibrous union	Visible fracture line with no bridging trabeculae, no movement on dynamic films and no implant failure.	7 (32%)
Pseudoarthrosis	Movement on dynamic films or implant failure	1 (4%)

Complications:

One patient had a misplaced screw passing immediately behind the odontoid fragment. He underwent a revision on the second postoperative day with satisfactory repositioning of the screw. He went on to a stable fibrous union, and was rated good on his latest follow up. Another patient on his 3 month follow up had an anterior cut through of the screw through the body of C2 with re-displacement of the fracture. He underwent a removal of the odontoid screw and atlanto-axial fusion. This is the patient with a poor clinical result in this series. We had no neurological or wound related complications in this series (Figure 3).

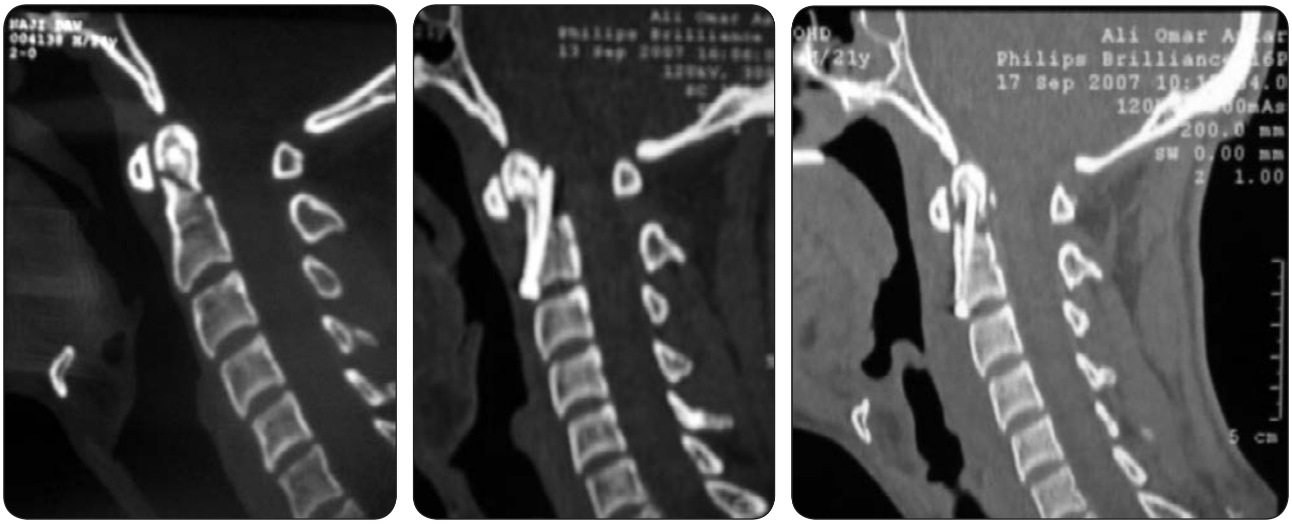

Figure 3. ND, 25 year old male sustained a type-IIB Odontoid fracture. Postoperative CT shows a posteriorly misplaced screw. Revision screw fixation was successfully done. Note the distraction at the fracture site. He went on to a stable fibrous union.

Discussion

Odontoid screw fixation has gained popularity as a method for treating type II and shallow type III Odontoid fractures. However, selection criteria and results have been variably reported in the literature.

Our bony healing rate is reportedly lower than that reported in other series[2,4,5,10,13,16,19,20,22,23,25,26,32] (Table 6). This may be related to a number of factors. First the selection criteria, as we have included some type IIC fractures which may not all be suitable for odontoid screw fixation. Grauer et al.,[17] believe that type IIC fractures are not suitable for odontoid screws. We agree with Cho and Sung[9] that some type IIC fractures particularly those with low angulations of the fracture line and low fracture fragment tilt can be fixed with an Odontoid screw. Second is the learning curve; indeed our technique improved with experience gained, particularly in overcoming the fracture gap and the entry point. We have learned to apply axial compression at the time of reduction before tightening the Mayfield frame, use partially threaded screws, avoid crossing of the fracture line by the threaded part of the screw and applying a downward pull to the screw head if a fracture gap persists after final screw tightening. In the beginning, we used to aim the entry point at the tip of C2. It became clear to us that this leads to a shallow path of the drill within the C2 body, risking an anterior cut through of the screw. Therefore, we modified this entry point to be deeply seated along the anterior part of the C2/3 disc. This allowed a deeper position of the screw and a better trajectory. This follows recent recommendations in the literature.

Stable fibrous unions occurred frequently in this series (32%). Most patients (6/7) were graded either good or excellent on clinical grounds, therefore no intervention was indicated. It may be that some of these fibrous unions will eventually go on to a bony healing with a longer follow up.

Table 6. Radiological Outcome of Type-II Odontoid Fractures Treated by Odontoid Screw in Different Series in Comparison to our Study.

Study	No of patients	No. of bony union	(%)Bony union
Andersson et al[4]	11	3	27
Apfelbaum et al[5]	117	99	85
Fountas et al[16]	31	27	87
Henry et al[20]	61	56	92
Harrop et al[19]	9	7	78
Jenkins et al[22]	42	30	71
Montesano et al [26]	14	12	86
Mashhadinezhad et al[25]	15	13	87
Konieczny et al[23]	13	12	92
Aldrian et al [2]	25	22	87
Wang et al[32]	42	40	95
Cho & Sung [10]	41	33	81
Eap et al [13]	36	34	95
Our study	22	14	64

In one case, a residual anterior displacement of the odontoid was present at the time of instrumentation. We have use digital trans-oral manipulation to push the odontoid fragment posteriorly as described without success[14]. So instead, we applied a Caspar pin to body of C2 and used it to pull the C2 body anteriorly with the help of a curved curette within the fracture. This maneuver was successful and allowed obtaining an anatomical reduction. To the best of our knowledge, this technical maneuver has not been described before (Figure 4).

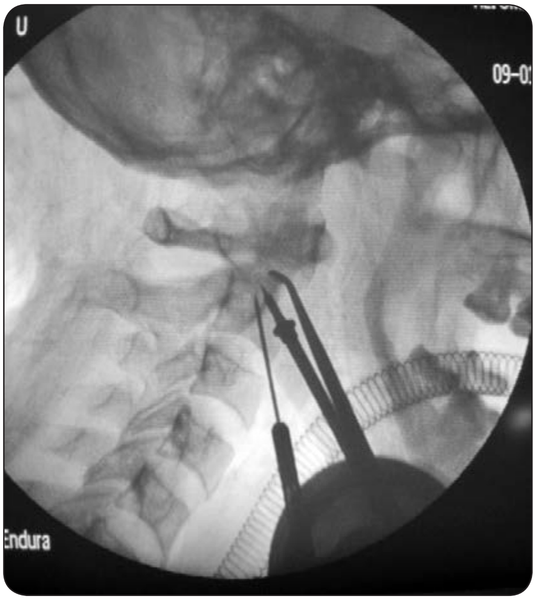

Figure 4. A technical maneuver used in a case with persistent anterior displacement of the odontoid fragment. A Caspar pin inserted and an angled curette into the fracture to pull the C2 body anteriorly.

We have used a single screw in our series. Biomechanical as well as clinical studies comparing one or two screws have confirmed the efficacy of a single screw in type II odontoid fractures[15,22,30].

A number of studies have reported complications related to Odontoid screw fixation, the incidence reported being as high as 24% of clinically relevant complications[4,29]. In our study, two patients (9%) showed significant complications; one with a misplaced screw that was successfully revised and another developed a cut through of the Odontoid screw at three months follow-up. He required revision removal of the screw and atlanto-axial fusion. We had no neurological, major vascular, visceral or wound related complications. Our relatively low complication rate confirms the safety of this procedure. Of note, however, is the difference in patient population; our series included young adult patients with a mean age of 32.5 years, which is significantly younger than that reported in other studies. This may have contributed to the lower incidence of complications in our series.

Conclusion

This study confirms the data of previous studies concerning odontoid screw fixation as a modality for treating types II odontoid fractures, since it offers high union rates, preservation of the range of rotation between C1 and C2, which is deficient in posterior atlanto-axial fusion, and also safety proved by low complication rate. With the experience gained and better patient selection higher bony healing rates are expected with Odontoid screw fixation.

References

1. Aebi M, Etter C, Coscia M: Fracture of the odontoid process: treatment with anterior screw fixation. Spine 14: 1065-1 070, 1989
2. Aldrian S, Erhart J, Schuster R, Wernhart S, Domaszewski F, Ostermann R, Widhalm H, Platzer P: Surgical vs nonoperative treatment of Hadley type IIA odontoid fractures. Neurosurgery 70(3):676-82; discussion 682-3, 2012
3. Anderson LD, D'Alonzo RT: Fractures of the Odontoid Process of the Axis. J Bone Joint Surg [Am]56: 1663, 1974
4. Andersson S, Rodrigues M, Olerud C: Odontoid fractures: high complication rate associated with anterior screw fixation in the elderly. Eur Spine J 9(1):56-9, 2000
5. Apfelbaum RI, Lonser RR, Veres R, Casey A: Direct anterior screw fixation for recent and remote odontoid fractures. Neurosurg Focus 8 (6):2, 2000
6. Apfelbaum RI: Screw fixation of the upper cervical spine: indications and techniques. Contemp Neurosurg 16:1-8, 1994
7. Apuzzo ML, Heiden JS, Weiss MH, Ackerson TT, Harvey JP, Kurze T: Acute fractures of the odontoid process. An analysis of 45 cases. J Neurosurg 48: 85-91, 1978
8. Borne GM, Bedou GL, Pinaudeau M, Cristino G, Hussein A: Odontoid process fracture osteosynthesis with a direct screw fixation technique in nine consecutive cases. J Neurosurg 68:223-226,1988
9. Cho DC, Sung JK: Is All Anterior Oblique Fracture Orientation Really a Contraindication to Anterior Screw Fixation of Type II and Rostral Shallow Type III Odontoid Fractures? J Korean Neurosurg Soc 49: 345-350, 2011
10. Cho DC, Sung JK: Analysis of risk factors associated with fusion failure after anterior odontoid screw fixation. Spine 37(1):30-4, 2012
11. Clark CR, white AA: Fractures of the dens. A multicenter study. J bone joint surg. 67:1340-1348, 1985
12. Crockard HA, Heilman AE, Stevens JM: Progressive myelopathy secondary to odontoid fractures: Clinical, radiological and surgical features. J Neurosurg 78:579-586, 1993
13. Eap C, Barresi L, Ohl X, Saddiki R, Mensa C, Madi K, Dehoux E: Odontoid fracture anterior screw fixation: a continuous series of 36 cases. Orthop Traumatol Surg Res 96(7):748-52, 2010
14. Elias WJ, Ireland P, Chadduck JB. Transoral digitally manipulated reduction of a ventrally displaced Type II odontoid fracture to aid in screw fixation. Case illustration J Neurosurg Spine 4:82, 2006
15. Feng G, Wendlandt R, Spuck S, Schulz AP: One-screw fixation provides similar stability to that of two-screw fixation for type II dens fractures. Clin Orthop Relat Res 470(7):2021-8, 2012
16. Fountas KN, Kapsalaki EZ, Karampelas I, Feltes CH, Dimopoulos VG, Machinis TG, Nikolakakos LG, Boev AN 3rd, Choudhri H, Smisson HF, Robinson JS: Results of long-term follow-up in patients undergoing anterior screw fixation for type II and rostral type III odontoid fractures. Spine 30(6):661-9, 2005
17. Grauer JN, Shafi B, Hilibrand AS: Proposal of a modified, treatment-oriented classification of odontoid fractures. Spine J 5:123-129, 2005
18. Hadley MN, Browner CM, Sonntag VKH: Axis fractures: a comprehensive review of management and treatment in 107cases. Neurosurgery 17:281-290, 1985
19. Harrop JS, Przybylski GJ, Vaccaro AR, Yalamanchili

K: Efficacy of anterior odontoid screw fixation in elderly patients with Type II odontoid fractures. Neurosurg Focus 8:E6, 2000

20. Henry AD, Bohly J, Grosse A: Fixation of odontoid fractures by an anterior screw. J Bone Joint Surg Br 81(3):472-7, 1999
21. Jeanneret B, Magerl F: Primary posterior fusion C1/2 in odontoid fractures: indications, technique, and results of transarticular screw fixation. J Spinal Disord 5:464-475, 1992
22. Jenkins JD, Coric D, Branch CL Jr: A clinical comparison of one- and two-screw odontoid fixation. J Neurosurg 89(3):366-70, 1998
23. Konieczny MR, Gstrein A, Müller EJ: Treatment algorithm for dens fractures: non-halo immobilization, anterior screw fixation, or posterior transarticular C1-C2 fixation. J Bone Joint Surg Am 94(19):E144(1-6), 2012
24. Lind B, Nordwall A, Sihlbom H: Odontoid fractures treated with halo-vest. Spine 12: 173-177, 1987
25. Mashhadınezhad H, Samini F, Mashhadınezhad A, Bırjandınejad A: Clinical Results of Surgical Management in Type II Odontoid Fracture: A Preliminary Report. Turkish Neurosurgery 22(5):583-587, 2012
26. Montesano PX, Anderson PA, Schlehr F, Thalgott JS, Lowrey G: Odontoid fractures treated by anterior odontoid screw fixation. Spine 16(3 Suppl):S33-7, 1991
27. Nourbakhsh A, Shi R, Vannemreddy P, Nanda A: Operative versus nonoperative management of acute odontoid Type II fractures: a meta-analysis. J Neurosurg Spine 11(6):651-8, 2009
28. Patel AA, Lindsey R, Bessey JT, Chapman J, Rampersaud R: Spine Trauma Study Group. Surgical treatment of unstable type II odontoid fractures in skeletally mature individuals. Spine 35(21 Suppl):S209-18, 2010
29. Rizvi SA, Fredo HL, Lied B, Nakstad PH, Ronning P, Helseth E: Surgical management of acute odontoid fractures: surgery-related complications and long-term outcomes in a consecutive series of 97 patients. J Trauma Acute Care Surg 72(3):682-90, 2012
30. Sasso R, Doherty BJ, Crawford MJ, Heggeness MH: Biomechanics of odontoid fracture fixation. Comparison of the one and two screw technique. Spine 18:1950-1953,1993
31. Sherk HH: Fractures of the atlas and odontoid process. Orthop Clin North Am 9:973-983,1978
32. Wang J: Zhou Y, Zhang ZF, Li CQ, Zheng WJ, Liu J. Comparison of percutaneous and open anterior screw fixation in the treatment of type II and rostral type III odontoid fractures. Spine 36(18):1459-63, 2011
33. Webster FS, Smiley DP: End result study of a series of operations for herniated intervertebral lumbar discs. Am J Surg 99:27–32, 1960

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الملخص العربي

علاج كسور السني بواسطة المسمار الأمامي السني

البيانات السابقة: لقد استخدمت عدة طرق لعلاج كسور السني. وتراوحت هذه من العلاج التحفظي إلى الالتحام الجراحي بين الفقرتين العنقية الأولى والثانية والتثبيت بواسطة المسمار السني يكتسب شعبية.

الغرض: دراسة استطلاعية لتحديد مدى فعالية وسلامة تثبيت المسمار السني في علاج كسور السني وتقديم تقرير عن النتائج السريرية والإشعاعية.

تصميم الدراسة: أفواج المرضى المحتملين لكسور السني يتم تثبيت كسورهم بواسطة المسمار الأمامي السني.

المواد والأساليب: أدرج اثنين وعشرين مريضا، ١٧ ذكور و٥ إناث، مع متوسط العمر ٣٢,٥ سنة في هذه الدراسة. كانت هذه الكسور من النوع الثاني في ١٩ مريضا وفي ٣ من النوع الثالث الضحل. وخضع جميع المرضى للتثبيت السني باستخدام مسمار واحد. وكان متوسط وقت الجراحة ٨٠ دقيقة ومتوسط فقدان الدم ١٥٠ مل.

النتائج: تمت متابعة المرضى لمدة متوسطة قدرها ٢٠,٦ شهرا. حصل تسعة عشر مريضا (٨٧٪) على نتيجة جيدة أو ممتازة على مقياس ويبستر. وحصل أربعة عشر مريضا (٦٤٪) على التحام عظمي، و٧ مرضى (٣٢٪) على التحام ليفي مستقر ومريض واحد (٤٪) على عدم التئام كامل.

مناقشة: كان معدل الالتحام العظمي في هذه الدراسة أقل من ذلك المقدم في أبحاث أخرى. وهذا قد يكون متعلق بمعايير الاختيار لدينا، بما في ذلك ضم بعض الكسور النوع الثاني C غير المناسبة للمسمار السني. وثمة عامل آخر هو منحنى التعلم، خاصة في وجود نقطة دخول العميقة داخل جسم الفقرة العنقية الثانية والتغلب على الفجوة بالكسر.

الخلاصة: هذه الدراسة أثبتت فعالية وسلامة تثبيت كسر العظم السني بواسطة المسمار الأمامي السني في أنواع مختارة من النوع الثاني والثالث الضحل.