Triple Endobuttton Technique in Acromioclavicular Joint Reduction and Reconstruction

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Abstract

<u>Introduction</u>: Acromioclavicular joint (ACJ) dislocation is a common injury often affecting young athletes. Cyclist, ice hockey players, weight lifters, rugby players and martial exponents are the most common athletes sustaining these injuries. Majority of these athletes sustain high-grade injuries requiring surgical management to allow them to return to their sports. <u>Methods</u>: The author describes a new technique to reduce and maintain reduction of the coraco-clavicular interval, using 3 low profile metallic buttons technique. The fixation device comprises 3 endobuttons (Acufex, Smith & Nephew, Andover, MA) and 2 #5 Fibrewire™ suture. Two endobuttons will sit on the clavicle and the third will be flipped at the undersurface of the coracoid. The proposed advantages include a non-rigid fixation of the AC joint which maintains reduction yet allowing for normal movement at the joint. The "snow shoe" hold on cortical bone means that the implant should withstand cyclic loading without cutting out from the bone. The theoretical strength of the fixation is also superior than the original strength of the coraco-clavicular ligaments. The relatively low profile means that there is no need for removal of implant. <u>Results</u>: The author has utilised this fixation technique on 5 patients. All the patients had strong intraoperative fixation. Immediate, 2 weeks and 6 months postoperative radiographs demonstrated excellent reduction of the coracoclavicular interval and the AC joint. <u>Conclusion</u>: The short-term follow-up with this technique proves to be a safe and effective way for providing fixation for the ACJ.

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Key words: Acromio-clavicular ligament, Coraco-clavicular ligament, Coraco-clavicular interval, Endobutton

Introduction

Acromioclavicular joint (ACJ) dislocation is a common injury often affecting young athletes. Cyclist, ice hockey players, weight lifters, rugby players and martial exponents are the most common athletes sustaining the injuries. Majority of these athletes sustain high-grade injuries requiring surgical management to allow them to return to their sports. High-grade dislocations if left untreated will invariably lead to a painful joint and significant loss of strength in the affected upper limb. Many fixation techniques that employ rigid form of fixation have resulted in failures. This is because the ACJ is not a rigid joint. With full overhead elevation, the clavicle rises by up to 35 degrees and rotates on its long axis by 45 degrees; and with adduction and extension, it displaces by up to 35 degrees anteriorly and posteriorly. Any form of rigid fixation is therefore non-anatomical.

Currently, there are 4 main surgical treatment options for the dislocated ACJ:

1. Primary ACJ fixation (with pins, screws, suture wires, plates, hook plates) with or without ligament repair or reconstruction.[1]
2. Primary coraco-clavicular interval fixation (with Bosworth screw, wire, fascia, conjoint tendon or synthetic sutures) with or without incorporation of acromioclavicular ligament repair/reconstruction.[2,3]
3. Excision of the distal clavicle with or without coraco-clavicular ligament repair with fascia or suture, or coracoacromial ligament transfer.[4-6]
4. Dynamic muscle transfers with or without excision of the distal clavicle.[7]

The multitude of techniques described illustrates the fact that the ideal technique to treat a symptomatic ACJ dislocation remains to be found. The use of metal implants

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can be complicated by migration of these implants.[8-10] Muscle transfers are technically demanding and serve to dynamically pull the clavicle downwards through the action of the coracobrachialis and the biceps muscles. However in dislocation of the ACJ, the problem is one of a "sagging" upper limb and not a high riding clavicle. Hence, the pathology is not addressed by muscle transfer procedures. Furthermore, these procedures carry significant chance of injury to the musculocutaneous nerve, failure of the coracoid to heal to the clavicle or loss of screw fixation or screw breakage.

The author describes a technique to reduce and maintain reduction of the AC joint with the use of 3 endobuttons (Acufex, Smith & Nephew, Andover, MA) and 2 strands of #5 Fibrewire™ suture (Figs. 1a and 1b). The proposed advantage includes a non-rigid fixation of the AC joint which maintains reduction, yet allowing for normal movement at the joint. The "snow shoe" hold on cortical bone means that the implant should withstand cyclic loading without cutting out from the bone. The theoretical strength of the fixation is also superior than the original strength of the coraco-clavicular ligaments. The relatively low profile means that there is no need for removal of implant.

Indications/Contraindications

Most literature has supported conservative management for Rockwood's grade I and II injuries[11] whereas there is a general consensus that grade IV, V and VI injuries[12] are best treated with surgery.[13] The management of grade III injuries, however, remain controversial with proponents for and against surgical treatment.[1,14-16]

The author has utilised this technique for acute ACJ dislocations (less than 6 weeks), Neer's Type II clavicle fracture and for chronic ACJ dislocation. In chronic dislocation, in addition to using the endobuttons, biological reconstruction of the coraco-clavicular ligaments and acromion-clavicular ligaments are achieved with hamstring allograft. The contra-indications for the use of this technique include: coracoid fractures, lack of soft tissue coverage, a narrow coracoid and ongoing infections. The endobuttons need an intact cortex to be able to provide stable fixation.

Preoperative Plansning

Preoperative radiographic assessment of the patients included antero-posterior, Y-scapular, axillary and a Zanca[17] view of the AC joint. These views allow assessment of the severity of the dislocation and any associated clavicle fracture. Weight bearing views can assist in identifying and differentiating between Type I and II AC joint injuries. However, this differentiation is not important in clinical practice and in the author's view is not useful for subsequent management. Types III to VI injuries are easily diagnosed on plain radiographs and clinical examination.

Technique

Acute Cases

The patient is given general anaesthesia and placed in a beach chair position. A sabre cut incision is made spanning the ACJ to just proximal to the coracoid process. The supraclavicular nerves are identified and protected throughout the procedure. The trapezius-deltoid fascia is opened transversely. The deltoid is dissected off the anterior-superior clavicle subperiosteally, allowing visualisation of the coracoid process and the ACJ. Care should be taken not to damage the coraco-acromial ligament when dissecting the area between the clavicle and the coracoid. The trapezoid component of the coraco-clavicular ligament spans from the superior surface of the posterior half of the coracoid process. The conoid component is attached to the "coracoid knuckle" just posterior to the trapezoid attachment and runs cranially in an inverse cone shape to attach to the posterior margin of the clavicle at the junction of the middle and lateral one third.

In acute cases, the AC joint is usually easily reduced. This reduction is then maintained with direct pressure. The medial and lateral borders of the coracoid process are identified. A 4.5 mm drill bit is positioned on the superior aspect of the coracoid at the junction which it turns laterally. A drill hole is then made with care, making sure not to plunge the drill bit or fracture the coracoid (Fig. 2 and Fig. 3). A malleable retractor can also be placed inferior to the coracoid process to ensure the drill bit does not plunge too deep below the coracoid process. It is important that the direction of the drill is in the centre of the superior surface of the coracoid process to achieve an optimal fixation. Another 2 drill holes are then make using a 2.5 mm drill bit at 20 and 40mm from the distal end of the clavicle. This corresponds to the anatomical attachment of the trapezoid (men, 17 to 28 mm and women, 16 to 27 mm) and conoid ligaments (men, 34 to 50 mm and women, 29 to 44 mm).[18]

The 2 #5 Fiberwire™ are then looped around the endobutton through separate openings. The endobutton is then pushed through the coracoid hole with a Watson Cheyne periosteal elevator. The endobutton is subsequently flipped and its fixation is tested by pulling the free ends of the fibrewires. The free ends of the fibrewires are then passed through the 2 drill holes in the clavicle with Mayo needle and threaded through each endobutton individually. At all times your assistance helps maintain traction of the fibrewires so as to prevent the coracoid button from unflipping. The reduction is achieved by having your assistant push down on the clavicle end and getting a towel bolster to elevate the arm. Reduction can usually be achieved

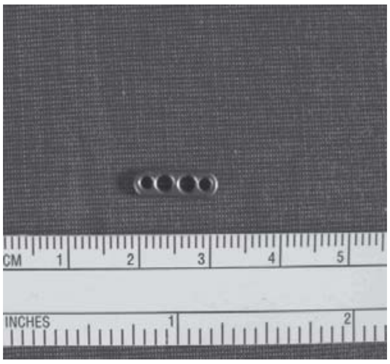

Fig. 1a. Endobutton.

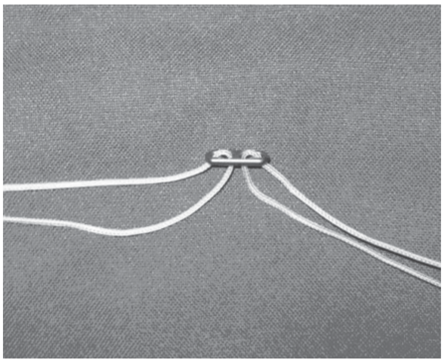

Fig. 1b. Endobutton with 2 strands of #5 fibrewire threaded through. This button is meant for the inferior surface of the coracoid process.

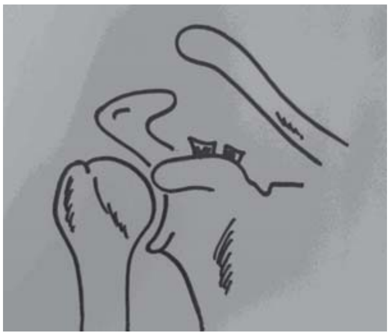

Fig. 2. Dislocated AC joint showing torn coracoclavicular ligaments.

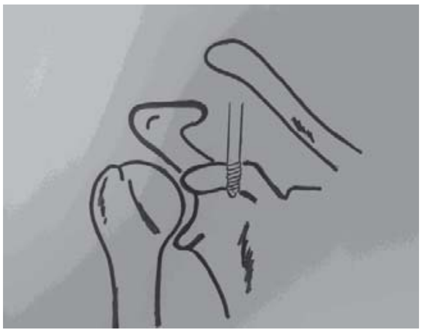

Fig. 3. Drilling through the coracoid process.

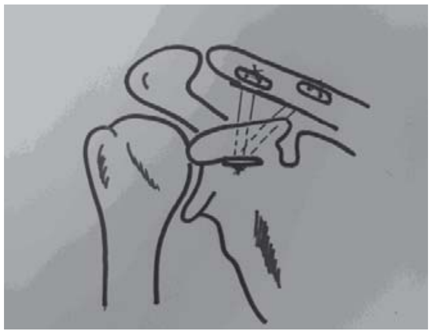

Fig. 4. One endobutton flipped and sitting on the undersurface of the coracoid process and the other 2 buttons tied on top of the clavicle.

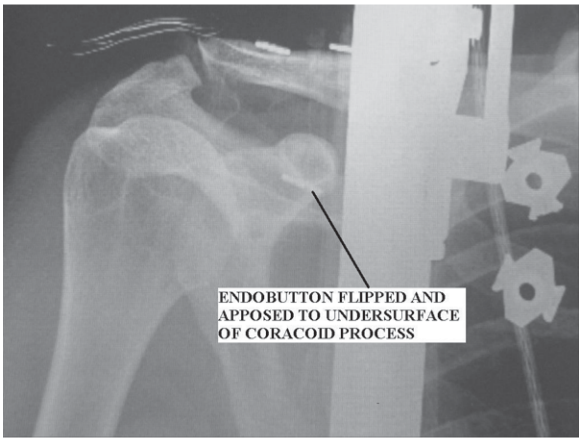

Fig. 5. An intraoperative X-ray showing the endobutton has flipped and apposed to the undersurface of the coracoid.

easily with this method. The fibrewires are then individually tied to each of their endobuttons (Fig. 4). An X-ray or image intensifier is used to confirm that the corocoid endobutton is flipped and closely apposing the inferior surface of the coracoid process (Fig. 5). The author's aim is to reproduce the normal coraco-clavicular interval and achieve anatomical reduction of ACJ. This should allow normal rotation of the clavicle on the fibrewire sutures. It should therefore not be over tight. Tension on the sutures should be aimed at achieving and maintaining adequate reduction, while allowing physiological motion. Subsequently, the conoid and trapezoid ligaments, superior part of the acromioclavicular ligament and trapezius-deltoid fascia are repaired.

Type II Clavicle Fracture

In Neer's Type II fracture of the clavicle,[19] the above method can also be used to reduce the fracture and maintain reduction provided the fracture has not consolidated. The author has used this technique to treat 2 cases with no loss of reduction on subsequent follow-up.

Chronic Cases

In chronic cases, the author recommends an excision of the distal end of the clavicle and an allograft or autograft reconstruction of the coracoclavicular and acromio-clavicular ligaments. The author prefers to utilise the allograft hamstring tendon as a graft. The role of adjunct fixation using the triple endobutton is to provide initial fixation to help reduce and maintain reduction until the graft has ligamentised.

It is important to mark out all the drill holes before excision of the clavicle. In order to achieve an anatomical reconstruction of both the trapezoid and conoid ligaments,

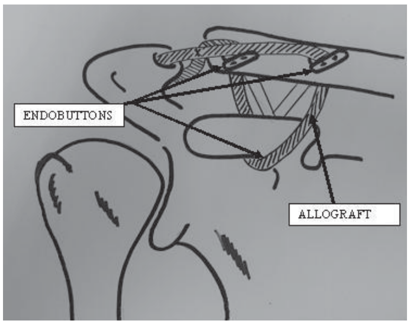

Fig. 6a. Passing the allograft beneath the coracoid process and then through the clavicle through the 2 drill holes. The free ends are then passed through the distal edge of the acromion to re-construct the acromioclavicular ligaments.

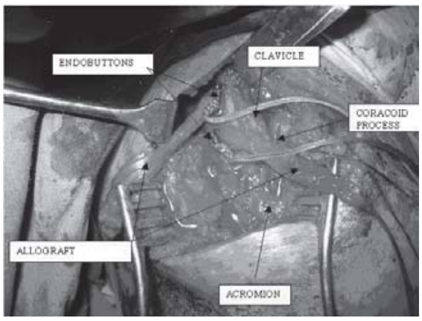

Fig. 6b. View of the superior surface of the clavicle. The suture has been tied over 2 endobuttons above the clavicles and the graft has been passed through the clavicle through the same drill holes.

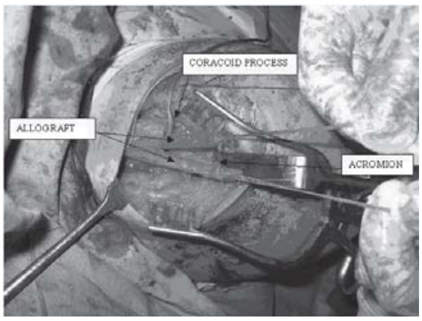

Fig. 6c. Pulling the graft across the acromioclavicular joint to re-construct the acromioclavicular ligament.

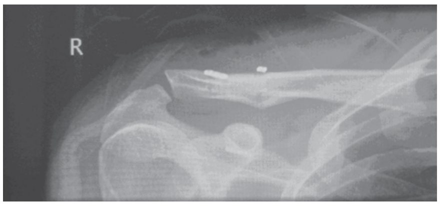

Fig. 7a. Zanca view of right ACJ of Patient A.

Fig. 7b. Zanca view of left ACJ of Patient B.

Fig. 7c. Zanca view of left ACJ of Patient C.

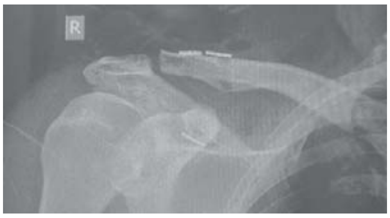

Fig. 7d. Zanca view of right ACJ of Patient D.

Fig. 7e. Zanca view of right ACJ of Patient E.

the lateral most drill hole for the passage of the hamstring graft should be about 20 mm[18] from the distal end of the clavicle. It should also be placed slightly anterior to the centre on the superior surface of the clavicle. The medial drill hole should be placed about 40 mm[18] from the distal end of the clavicle. The medial drill hole should be positioned posteriorly on the superior surface of the clavicle. There should be adequate bone bridges surrounding the drill holes. A 4.5 mm drill bit is used to create the drill holes on the superior aspect of the clavicle for the passage of the fibrewires and the graft. The placement of the fibrewires is then carried out as alluded above.

One centimetre of the distal end of the clavicle is then resected using a sagittal saw. A whip stitch is placed at both end of the graft using a #2 fibrewire. The passage of the graft under the coracoid process is aided by using a gall-bladder clamp under the coracoid process (Figs. 6a to 6c). The graft is passed under the coracoid process and then with the help of a Mayo needle passed through the drill holes previously made. Once the graft is in a satisfactorily position, the clavicle is reduced and the #5 fibrewires secured onto the endobutton. The free ends of the graft are then brought through a drill hole on the acromion and tied onto each other with #2 fibrewires. The graft is then further secured to each other and the clavicle by using the free ends of the #5 fibrewires from the endobutton. This reconstructs both the coraco-clavicular as well as the acromioclavicular ligaments.

Results

The author has utilised this fixation technique on 5 patients. Four patients were male while 1 was female. They had a mean age of 37 years (range, 25 to 47). The dominant limb was involved in 3 out of 5 cases. Indications of the procedure included: a grade V ACJ dislocation (1 patient), grade IV ACJ dislocation (1 patient), chronic grade III ACJ dislocation (1 patients) and distal clavicle fracture (2 patients). Four of the 5 patients were operated within 6 weeks of their injury. In these acute cases, only endobutton fixation and repair of the CC ligaments were used to reduce the coracoclavicular interval. In the one chronic case, a coracoclavicular ligament reconstruction using hamstring allograft was performed in addition to the endobuttons. Intraoperative satisfactory reduction and fixation was confirmed clinically and with intraoperative X-ray. Postoperatively, a sling was applied for 4 weeks with instructions of gentle range of motion up to the shoulder level. Light duties were allowed from 4 to 12 weeks and full duties resumed from 3 months onwards. Contact sports were discouraged for 6 months. Clinical and radiological follow-up was at 2 weeks, 6 weeks and 6 months. Minimum follow-up of 6 months is available for all the patients.

Intraoperative, 2-week and 6-month postoperative radiographs demonstrated excellent reduction of the coracoclavicular interval and the ACJ in all patients (Figs. 7a to 7e). At the final follow-up, all the patients had an uneventful recovery with no pain and resumption of full duties. Anatomical reduction of the ACJ was maintained. There were no iatrogenic coracoid or clavicle fractures.

The author has previously described the technique using Tightrope™ and its early for fixation of the ACJ.[20] That result was not entirely satisfactorily for a few postulated reasons. Firstly, the tightrope uses a same strand of #5 fibrewire to loop twice around the 2 endobuttons making it 4 strands thick, failure of any one strand will result in failure of the whole constructs. Secondly, the native coracoclavicular ligaments are not attached perpendicularly from the coracoid base. Anatomical studies have shown that the trapezoid ligament is attached distal to the junction where the coracoid process turns laterally while the conoid starts at the junction itself. The conoid ligament is directed medially and posteriorly and is attached to the clavicle posterior to the midline. The trapezoid ligament on the other hand is directed laterally and anteriorly and is attached to the clavicle anterior to the midline. There is therefore a gentle divergent from their origin to their attachment. The Tightrope™ does not allow this form of anatomical constructs and risks over-tightening the joint. With this new technique, the non-biological and biological (in the case of chronic dislocation) fixations are place in as anatomical position as possible. This reduces the risk of over-tightening the joint and at the same time maintaining its reduction while allowing motion of the joint. There is always a risk of abrasion of the sutures against the endobuttons or the drill holes when the sutures are not placed perpendicularly. However, if the sutures are placed in the central 2 holes of the endobutton and if they are not placed at too steep an angle this should only be a theoretical concern.

There were no neurovascular infections or other complications in this series. There is a potential for late development of symptomatic osteoarthritis of ACJ, which may necessitate a delayed excision of distal clavicle.

The tensile strengths of the native coracoacromial ligaments and a single #5 fibrewire are highly comparable, with reported values of about 500N[21] and 483N[22] respectively. The pullout strength of a metallic button has been shown to be in excess of 1150N.[23] The use of 4 strands of #5 fibrewire to hold 3 metallic buttons to close the coracoclavicular interval is, at least theoretically, a much stronger repair than the native ligaments, coracoclavicular slings, suture anchors or coracoacromial ligament transfers.[21] Furthermore, it provides a non-rigid fixation of the AC joint, thus allowing normal rotation of the clavicle. This is an attractive advantage of this technique. In contrast, techniques utilising screws do not allow for this rotation and screws usually work loose due to repetitive strains placed on the screw bone interval. The endobuttons protect the sutures from cutting through the clavicle, a failure mode often seen when using isolated sutures. The low profile of the implant eliminates the need for a second operation for removal of the implant.

The concept of this fixation technique is good and provides very strong intraoperative fixation in addition to other potential benefits as outlined above. To the best of the author's knowledge, there are no published studies in the English literature on the use of 3 endobuttons in reconstructing the ACJ dislocations.

REFERENCES

1. Phillips AM, Smart C, Groom AFG. Acromioclavicular dislocation: conservative or surgical therapy. Clin Orthop Relat Res 1998;353:10-17.
2. Boswoth BM. Acromioclavicular separations: new method of repair. Surg Gynecol Obstet 1941;73:866-71.
3. Larsen E, Petersen V. Operative treatment of chronic acromioclavicular dislocation. Injury 1987;18:55-6.
4. Weaver JK, Dunn HK. Treatment of acromioclavicular injuries, especially complete acromioclavicular separation. J Bone Joint Surg Am 1972;54:1187-94.
5. Urist MR. Complete dislocation of the acromioclavicular joint. J Bone Joint Surg Am 1963;45:1750-3.
6. Mumford EB. Acromioclavicular dislocation. J Bone Joint Surg 1941;23:799-802.
7. Berson BL, Gilbert MS, Green S: Acromioclavicular dislocations: treatment by transfer of the conjoined tendon and distal end of the coracoid process to the clavicle. Clin Orthop Relat Res 1978;135: 157-64.
8. Norrell H, Llewellyn RC. Migration of a threaded Steinman pin from the acromioclavicular joint to the spinal canal: a case report. J Bone Joint Surg Am 1965;47:1024-6.
9. Lindsey RW, Gutowski WT. The migration of a broken pin following fixation of the acromioclavicular joint: a case report and review of literature. Orthopaedics 1986;9:413-6.
10. Lyons FA, Rockwood CA. Migration of pins used in operations on the shoulder. J Bone Joint Surg Am 1990;72:1262-7.
11. Tossy JD, Mead NC, Sigmond HM. Acromioclavicular separations: useful and practical classification for treatment. Clin Orthop Relat Res 1963;28:111-9.

12. Williams GR, Nguyen VD, Rockwood CA. Classification and radiographic analysis of acromioclavicular dislocations. Appl Radiol 1989:29-34.
13. Urist MR. Complete dislocation of the acromioclavicular joint: the nature of the traumatic lesion and effective methods of treatment with an analysis of 41 cases. J Bone Joint Surg 1946;28:813-37.
14. Cox JS. The fate of the acromioclavicular joint in athletic injuries. Am J Sports Med 1981;9:50-3.
15. Schlegel TF, Burks RT, Marcus RL. A prospective evaluation of untreated acute grade III acromioclavicular separations. Am J Sports Med 2001;29:699-703.
16. Press J, Zuckerman JD, Gallagher M, Cuomo F. Treatment of grade III acromioclavicular separations. Operative versus nonoperative management. Bull Hosp Jt Dis 1997;56:77-83.
17. Zanca P. Shoulder pain: involvement of the acromioclavicular joint. (Analysis of 1,000 cases). Am J Roentgenol Radium Ther Nucl Med 1971;112:493-506.
18. Renfree KJ, Riley MK, Wheeler D, Hentz JG, Wright TW. Ligamentous anatomy of the clavicle. J Shoulder Elbow Surg 2003;12:355-9.
19. Neer CS II. Fracture of the distal clavicle with detachment of the coracoclavicular ligaments in adults. J Trauma 1963;3:99-110.
20. Lim YW, Sood A, Riet RP, Bain GI. Acromioclavicular joint reduction, repair and reconstruction using metallic buttons – early results and complications. Technique Shoulder Elbow Surg 2007;8:213-21.
21. Harris RI, Wallace AL, Harper GD, Goldberg JA, Sonnabend DH, Walsh WR. Structural properties of the intact and the reconstructed coracoclavicular ligament complex. Am J Sports Med 2000;28:103-8.
22. Barber FA, Herbert MA, Richards DP. Sutures and suture anchors: Update 2003. Arthroscopy 2003;19:985-90.
23. Greenberg JA, Fernandez JJ, Wang T, Turner C. Endobutton-assisted repair of distal biceps tendon ruptures. J Shoulder Elbow Surg 2003;12:484-90.