We conducted a prospective, randomised, controlled trial of 45 patients (47 elbows), with tennis elbow, who underwent either a formal open release or a percutaneous tenotomy. All patients had pre- and post-operative assessment using the Disability of Arm, Shoulder and Hand (DASH) scoring system. Both groups were followed up for a minimum of 12 months. Statistical analyses using the Mann-Whitney U test and repeated measured ANOVA showed significant improvements for patient satisfaction (p = 0.012), time to return to work (p = 0.0001), improvements in DASH score (p = 0.001) and improvement in sporting activities (p = 0.046) in the percutaneous group. Those patients undergoing a percutaneous release returned to work on average three weeks earlier and improved significantly more quickly than those undergoing an open procedure. The percutaneous procedure is a quicker and simpler procedure to undertake and produces significantly better results.

Tennis elbow or lateral epicondylitis refers to a syndrome of pain centred over the common origin of the extensor muscles of the fingers and wrist at the lateral epicondyle. It was first reported in the literature in 1873 by Runge.1 It occurs more commonly in non-athletes than athletes and has a peak incidence in the fifth decade. The term epicondylitis is a misnomer as there is little evidence to suggest that there is an inflammatory process. It may be caused by repeated microtrauma to the origin of extensor carpi radialis brevis (ECRB) but the precise aetiology and pathology remains unclear.1,2

The diagnosis of tennis elbow is usually made by localising pain when the patient pinches with the wrist in extension and on resisted extension of the middle finger. The differential diagnosis can include radial tunnel syndrome, lateral compartment arthritis and osteochondritis of the capitellum.

The initial treatment is with rest, modification of activity, local splints, and steroid injection, and 90% of patients respond to conservative treatment.2 Steroid injections may provide relief of symptoms in up to 40% of patients. Patients who fail to respond to conservative measures may require surgery. Boyd and McLeod,1 and Posch, Goldberg and Larrey4 reported that up to 8% of patients require surgery.

The many operations available have been reviewed by Bosworth5 and Rosen et al,6 and include tenotomy of the extensor tendon, excision of the damaged portion of the tendon, exploration of the radiohumeral joint and alterations to the length of the tendon of ECRB.

The purpose of this study was to compare the efficacy of two operative techniques; the open technique as described by Nirschl7 and a percutaneous division of the common extensor origin as described by Yerger and Turner,1 Rosen et al,6 and Baumgard and Schwartz.8

Patients and Methods

We carried out a prospective, controlled trial in which patients were randomised to one of two groups using sealed envelopes. Group one underwent an open and group two a percutaneous procedure. All patients had previously undergone conservative treatment for 12 months. This included two injections of 80 mg of hydrocortisone into the common extensor origin and modification of activity, which involved them refraining from repetitive activities that provoked pain over the lateral epicondyle.

All patients were examined pre-operatively. The diagnosis was confirmed by resisted extension of the middle finger and pinch grip with the wrist in extension provoking pain over the common extensor region. On examination all patients had a normal cervical spine. All were assessed pre-operatively using the American Academy of Orthopaedic Surgeons Disability
of Arm, Shoulder and Hand (DASH) score. This outcome measure is a 30-item questionnaire designed to measure function and assess symptoms in patients with musculoskeletal disorders of the upper limb. It includes a disability measurement index for general function and symptoms as well as sport and music function, and high performance work function. It is scored as a single scale, with each of the 30 items scored on a scale of 1 to 5. A raw score of 150 points indicates maximum and 30 points, minimum disability. In order to convert the raw score to a scaled score, 30 is subtracted from the total, which is then multiplied by 0.8, yielding a scaled range from 0 to 100. The specialist score for high demand work, sport or musical activities is calculated in a similar manner. The procedures were all carried out under general anaesthesia and tourniquet control by the same surgeon (BNM). The post-operative physiotherapy regime was identical for both groups and was supervised by the same physiotherapist. The patients were followed up at one year post-operatively. Their subjective assessment and the time off work were recorded as well as the DASH score.

Anatomy.
The anatomy of the common extensor origin has been well described and consists of the tendons of extensor carpi radialis longus (ECRL) and ECRB, extensor digitorum, extensor carpi ulnaris and anconeus. The tendons of origin may combine as a confluent mass. The tendon of ECRB arises from the anterior aspect of the lateral epicondyle and is deep and inferior to that of ECRL and extensor digitorum communis. The lateral collateral ligament is a primary stabiliser of the elbow and care must be taken to protect it. The body of ECRL is easily identified.

Operative technique
Open procedure. The open procedure used the technique described by Nirschl and Nirschl and Pettrone. A 7 cm incision is centred over the common extensor origin and ECRL is reflected to expose the origin of ECRB and the damaged portion of the tendon is removed. This is commonly found to be white and oedematous. Three small drill holes are made in the lateral epicondyle. The radiocapitellar joint is explored to check for degenerative changes or synovitis.

Percutaneous technique. The percutaneous technique involves a 1 cm incision over the mid-point of the lateral epicondyle to reveal the common extensor origin. The elbow is flexed to protect the radial nerve. A small pair of artery forceps is manoeuvred under the common extensor origin which may, thus, be well visualised. It is divided (Fig. 1). The wrist is flexed to complete the defect and allow a 1 cm gap to be created at the common extensor origin. This gap is palpated to confirm that the procedure is complete. The wound is closed and local pressure applied to create haemostasis when the tourniquet is released.

A wool and crepe bandage was applied in both groups and was removed after seven days to allow the early commencement of an exercise programme. The post-operative physiotherapy regime was identical for both groups.

Statistical analysis. Demographic and outcome data were collected and presented as mean (SD), median (inter-quartile range) and count as appropriate. Means were analysed using unpaired Student’s t-tests for differing variances, medians by Mann-Whitney U tests, and counts or proportions by Fisher-Freeman-Halton generalised exact tests. Data were examined by frequency histograms, normal probability plots and the Shapiro-Wilk tests for Gaussian distribution. All scores were normalised by use of the ln (1 + x) transformation as the data was positively skewed. The effects of operation, time and time-operation interaction were examined in a two-way repeated measured analysis of variance (ANOVA) design with Tukey-Kramer multiple comparison post-tests. For these analyses we used the following software: Excel 2000 (Microsoft Corp., Redmond, Virginia) and Number Crunching Statistical System (NCSS) 2001 (NCSS Inc., Kaysville, Utah). Statistical significance was defined for overall α error at the 0.05 level. All p values were two-sided. For the statistical analysis we used the normalised scores data rather than the raw data.

Results
There were 45 patients (47 elbows) in the study. Of the 47 elbows, 24 were in the open group and 23 in the percutaneous group. The groups were similar in respect of demo-
graphic and pre-test variables (Table I) and there were no significant differences.

Most of the post-test scoring data were significantly positively skewed and, therefore, were all subjected to ln (1 + x) transform prior to ANOVA. The median pre-operative co-morbidity scores were 2 (0.25 to 2) in the open group and 2 (1 to 3) in the percutaneous group and were not significant (Table I).

The median pre-operative basic DASH raw score was 78 (67 to 86) for the open group and 77 (68 to 95) for the percutaneous group. As shown in Tables II and III the median basic normalised DASH score was 70 (64 to 75) in the open and 70 (64 to 80) in the percutaneous group. The median post-operative basic normalised DASH score was 53 (48 to 57) in the open and 49 (46 to 51) in the percutaneous group. The change in the median basic DASH score for the open group was 17 (11 to 19) compared with 20 (18 to 26) for the percutaneous group. This was highly significant (p = 0.0011 Mann-Whitney U Test). The sport function section of the DASH score showed pre-operative normalised median scores of 68 (65 to 78) and 70 (62 to 76) for the open and percutaneous groups, respectively. The change in the median normalised sport scores was 11 (6 to 19) and 19 (11 to 25) in the open and percutaneous groups, respectively. This was also highly significant (p < 0.046). The patients were also scored according to the high performance work section of the DASH questionnaire. The median pre-operative work score was 68 (60 to 72) in the open compared with 72 (62 to 79) in the percutaneous group. The median post-operative score was 52 (49 to 59) and 49 (45 to 52) in the open and percutaneous groups, respectively, producing a change in median score of 14 (7 to 20) in the open group and 24 (10 to 27) in the percutaneous group (p < 0.11).

The patient's subjective assessment was recorded (Table IV) and showed that in the open group two patients were dissatisfied, 16 were satisfied and six were very pleased with the outcome. This compared with no patients who were dissatisfied, nine who were satisfied and 14 who were very pleased with the outcome in the percutaneous group. These differences were significant (p = 0.012).

It should be noted that one of the patients who was dissatisfied with the outcome and was in the open group was taking legal proceedings against their employer. This patient had a change in the DASH normalised score of only 8 (from 99 to 91), a change in normalised sport score of 24 (from 81 to 57), but no change in the normalised work score (pre-operative 79, post-operative 79). There were no other compensation claims in progress and no other patient attributed their condition solely to their occupation.

In the open group, 16 patients were engaged predominantly in manual work and seven were office and non-manual workers. In the percutaneous group 14 were manual workers and eight were non-manual workers. As shown in Table V the median time off work in the open group was five weeks (4 to 6) compared with two weeks (2 to 3) in the percutaneous group (p < 0.0001).

**Discussion**

The treatment of tennis elbow has been the subject of much debate. Numerous surgical techniques have been described including fasciotomy, z-lengthening of the tendon, osteot-
omy of the lateral epicondyle and excision of the damaged portion of ECRB as well open and percutaneous tenotomy.\textsuperscript{1,4,7-10} Arthroscopy has also been advocated.\textsuperscript{11} There are, however, few prospective randomised controlled trials in the literature and most techniques are advocated by surgeons who specialise in a single procedure. Grundberg and Dobson\textsuperscript{10} reported good or excellent results in 29 of 32 elbows and Baumguard and Schwartz\textsuperscript{8} achieved 32 excellent and three dissatisfied patients in 35 elbows following percutaneous release. Nirschl and Pettrone\textsuperscript{9} achieved an excellent outcome in 66 of 88 elbows using an open technique similar to the technique used in this study. Our results compare favourably with these results and show that the percutaneous procedure produces significantly better results than an open procedure. Patients in the percutaneous group had significantly improved basic DASH scores, sporting and high demand work scores and the time off work was significantly less in the percutaneous group. The subjective outcome was also significantly better in the percutaneous group.

Although we do not advocate that all patients should be treated surgically, our results indicate that if surgery is being considered the percutaneous procedure gives significantly better results than a formal open procedure. It is quicker and, although we carried it out under general anaesthesia, it may be undertaken under local anaesthesia.\textsuperscript{1} The procedure was safe in our patients and without significant complications. The rationale of the percutaneous technique is that once the common extensor origin has been released the damaged portion of the tendon may heal. Lack of certainty as to the diagnosis may lead to a poor outcome as, for instance, radial tunnel syndrome may be responsible for 5\% of the symptoms.\textsuperscript{12} We recommend the percutaneous technique when considering surgery on patients with tennis elbow.

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No benefits in any form have been received or will be received from a commercial party related directly or indirectly to this article.

References