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ORIGINAL STUDY

Fluid temperatures during arthroscopic subacromial decompression using a radiofrequency probe

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Our aim was to investigate the temperatures reached in the subacromial space during radiofrequency ablation of the subacromial bursa, in order to see if the probes generate sufficiently high temperatures to cause chondrolysis of the articular surfaces in the glenohumeral joint. We recorded the maximum temperatures in the subacromial space during arthroscopic subacromial decompression on 30 consecutive patients using a sterile digital temperature probe (Series 400, DeRoyal, TN, USA). Both the mean (27.8°C) and maximum (41.8°C) temperatures reached were below the experimental thresholds for chondrocyte damage. At 2 year follow-up we report no cases of chondrolysis or other complications related to the radiofrequency probes and conclude that given the relatively low maximum temperatures generated by the probes the risk of adverse effects is minimal.

Keywords : subacromial decompression ; arthroscopy ; fluid temperature.

INTRODUCTION

Arthroscopic decompression has become a commonly used procedure for the surgical management of subacromial impingement syndrome in the shoulder (*1-2,4-5,6,10,14,18,20*). This has been made possible by the introduction of radiofrequency (RF) probes that allow the surgeon to ablate the subacromial bursa whilst maintaining a clear visual field. However, concern has been raised that the thermal energy generated by the RF probes may cause undesired chondrocyte damage in the glenohumeral joint, particularly if excessive temperatures are reached. Complications secondary to RF probe use such as rupture of the biceps tendon (*8*) and axillary nerve damage (*16*) have already been reported.

A majority of cases of chondrolysis following the use of RF probes have occurred following either capsulorrhaphy (*7,13,19*) or capsular release (*11*). Whilst there is no direct evidence to suggest that RF probes cause chondrolysis during subacromial decompression, both animal (*9,12*) and laboratory

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studies (21) report chondrocyte damage at temperatures as low as 45°C (3). Even without direct contact by the RF probe, heated normal saline solution can cause irreversible articular cartilage damage with temperatures of 48°C for 10 minutes (22).

The aim of this study was to record the maximum temperatures in the subacromial space during arthroscopic subacromial decompressions using a monopolar radiofrequency ablator probe in order to ascertain the likelihood of damage to articular cartilage.

MATERIALS AND METHODS

Data was collected prospectively from thirty consecutive patients who underwent an arthroscopic subacromial decompression between August and November 2005.

Arthroscopy was performed using 3 standard portals (posterior, anterior and lateral) in 28 of the patients. A further 2 portals were created for 2 patients who underwent rotator cuff repair.

Resection of the subacromial bursa was performed in all cases using a monopolar electrosurgical radiofrequency probe with continuous integral suction (Ablator-S Monopolar Ablation probe, 90° with suction, using a Vulcan generator ; Smith and Nephew, Warwick, UK). Additional procedures such as acromioclavicular joint excision and rotator cuff debridement or repair were carried out as appropriate. Bone resection, if required was performed using an arthroscopic burr. The temperature of the fluid (0.9% Normal saline) within the subacromial space was continuously monitored using a sterile digital temperature probe (Series 400, DeRoyal, TN, USA) inserted through one of the portals. The tip of the temperature probe was placed within the vicinity of the RF device at the level of the subacromial bursa with the assumption being that we would then record the maximum temperature generated. The RF probe was only used in the subacromial space and did not come into contact with the articular surface. The starting and maximum temperatures were recorded, as was the duration of the procedure, infusion pressure and volume of fluid used.

Patients were assessed for signs of post operative chondrolysis by routine clinical examination and radiographs of the shoulder as required. Magnetic resonance imaging was used to further investigate the diagnosis if symptoms were persistent or there were changes on post operative radiographs.

Statistical analysis was undertaken using SPSS 15.0 (SPSS inc. Chicago, USA). Continuous data was analysed for differences with a two tailed Student's t test. The Pearson product moment correlation was used to investigate linear relationships between several of the variables measured.

RESULTS

Of the 30 patients who underwent surgery 9 patients had a full thickness rotator cuff tear, 7 of which were debrided and 2 of which were repaired. Seven patients had an acromioclavicular joint excision.

The mean operating time for all cases was 46 minutes (15-107 min).

Fluid

Mean infusion pressure : 55.6 mmHg (range 40-60).

Mean infused volume (all) : 3700 ml (range 1500-9000).

Mean infused volume (cuff intact) : 3475 ml.

Mean infused volume (cuff tear) : 5250 ml.

The difference in mean fluid volume between patients with intact rotator cuffs and those with cuff tears is statistically significant, $p = 0.03$ (Student's t test).

Temperature (infused saline)

Mean starting temperature : 22.7°C (range 19.6-25.4°C)

Mean maximum temperature : 27.8°C (range 22.7-41.8°C).

Mean maximum temp (cuff intact) : 28.3°C

Mean maximum temp (cuff tear) : 27.1°C

The difference in mean maximum temperature between those patients with an intact rotator cuff and those with a cuff tear is not statistically significant ($p = 0.53$).

The maximum temperatures recorded in each of the consecutive cases are illustrated in figure 1.

Using the Pearson product moment correlation we were able to demonstrate statistically significant linear relationships between several of the variables measured, including start and maximum temperature ; operative time and fluid volume used ; fluid

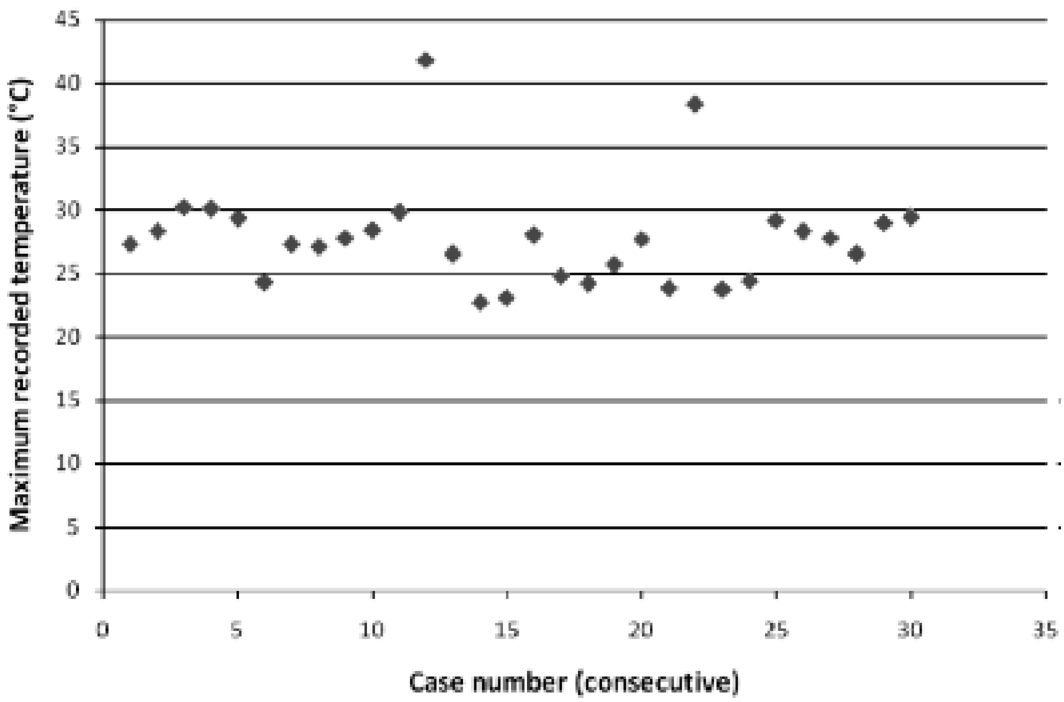

Fig. 1. — The maximum recorded temperature during each procedure

volume and flow rate ; and maximum temperature and temperature difference (table I).

At a minimum follow-up period of two years, none of the patients who underwent arthroscopic decompression with the RF probe have any evidence of chondrolysis.

DISCUSSION

In the 30 patients who underwent arthroscopic subacromial decompression using an RF probe, the maximum recorded temperature of 41.8°C was below the threshold for chondrocyte damage by both direct and indirect contact (*3,22*). However, whilst a mean maximum temperature of 27.8°C in the subacromial space seems to indicate that RF probes are safe for general usage for time periods extending upwards of 46 minutes, it should be noted that in all cases the ablator was used intermittently throughout the procedure. Probes that are left running continuously or used statically in a particular area may significantly raise the maximum fluid temperature (*15*). The isolated case where the maximum temperature was over 40°C was thought to have been caused by a partial blockage in the suction pump of the RF probe. However, as it is usually isolated incidents of equipment malfunction that can lead to adverse effects, this may give us some degree of reassurance that even with a blocked sucker the temperature did not rise to critical levels.

The linear relationship between the inflow temperature of the fluid and the maximum temperature ($p = 0.002$) in the subacromial space during surgery is indicative of the fact that to protect soft tissues from thermal injury during electrosurgery, we need to cool the fluid as much as is safe and practical prior to infusion. The other linear relationships (table I) simply confirm what we would expect from fluid dynamics during arthroscopy. For example, a prolonged procedure will use a large amount of fluid for a given pressure and the higher the maximum temperature in the subacromial space then the greater the temperature difference from the starting point.

Table I. — Statistically significant linear relationships between variables measured during the study

Relationship between recorded variables during surgery	Pearson product moment correlation
Start temperature-maximum temp (°C)	$p = 0.002$
Operative time (mins)-fluid volume (ml)	$p < 0.001$
Fluid volume (ml)-flow rate (ml/min)	$p = 0.001$
Maximum temp (°C)-temp difference (°C)	$p = 0.002$

Patients with rotator cuff tears have a direct connection into the glenohumeral joint and consequently have a larger subacromial space and use larger fluid volumes than patients with intact cuffs. As only 2 of the 7 patients with cuff tears had extra portals for cuff repair then it is unlikely that these larger fluid volumes are due to excessive loss from these portals rather than the size of the subacromial space. Heat energy is dissipated away from the tip of the RF probe by the infused fluid, therefore we would expect patients with smaller circulating fluid volumes (i.e. patients with intact cuffs) to have higher temperatures in the glenohumeral joint during surgery. Whilst the mean maximum temperature in patients with intact rotator cuffs (28.3°C) is higher than in patients with cuff tears (27.1°C) this is not statistically significant and as such means that patients without tears are probably no more likely to suffer chondrolysis due to the temperature effects of the RF probe. Patients with an intact cuff will also have a protective layer of tissue between the probe and the joint surface.

One of the criticisms of this study is that the temperature probes were inserted into the subacromial space rather than directly at the glenohumeral joint where any thermal damage was expected to have the greatest effect. However, cadaveric studies (*17*) have shown that the temperature away from the probe tip is very close to that of the fluid at the point of inflow. As the RF probe was always directed at the subacromial bursa the temperature would be highest at this point and would have been much lower at the articular surface. Another weakness of the study is that we only used one type of RF probe. It seems likely, however, that as most probes are manufactured to work in the same way, the results with other equipment would be comparable. Whilst we only report on a modest number of cases, the results show that in a majority of the patients the temperatures are well within safe limits and even with complications such as low inflow or a blocked suction unit they do not reach critical levels. On this basis we can be confident that a much larger series would not yield differing results.

In conclusion, RF probes used in an appropriate manner with adequate fluid flow do not present an excessive risk of damage to the cartilage of the glenohumeral joint. We recommend cooling inflowing fluid and ensuring suction units are not blocked.

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