The internervous safe zone for incision of the capsule of the hip

A CADAVER STUDY

R. J. Kampa, A. Prastrohofer, D. J. Lawrence-Watt, R. M. Pattison

From Royal Sussex County Hospital, Brighton

In order to determine the potential for an internervous safe zone, 20 hips from human cadavers were dissected to map out the precise pattern of innervation of the hip capsule. The results were illustrated in the form of a clock face. The reference point for measurement was the inferior acetabular notch, representing six o’clock. Capsular branches from between five and seven nerves contributed to each hip joint, and were found to innervate the capsule in a relatively constant pattern. An internervous safe zone was identified anterosuperiorly in an arc of 45° between the positions of one o’clock and half past two.

Our study shows that there is an internervous zone that could be safely used in a capsule-retaining anterior, anterolateral or lateral approach to the hip, or during portal placement in hip arthroscopy.

The hip joint is surrounded by a strong and dense capsule which is known to have mechanical, proprioceptive and nociceptive functions. It is recognised that retaining and repairing this capsule during the posterior approach for elective or trauma hip replacement offers greater mechanical stability and a reduced rate of dislocation. Proprioception and nociception of the hip joint are more complex properties regulated by both capsular and extra-capsular structures. Although the role of the capsule and its innervation in proprioception and nociception remains unclear, the principle of soft-tissue preservation is integral to minimally-invasive hip replacement. While numerous surgical approaches, both traditional and more modern, have been described and modified, very little attention has focused on the capsule.

We dissected human cadaver hips to define the pattern of capsular innervation and determine whether internervous safe zones exist for performing a capsular incision during surgery of the hip, thereby minimising trauma to the capsule and retaining its innervation.

Patients and Methods

We undertook 20 dissections on formalin-fixed human hips in ten male and ten female cadavers, with a mean age of 81 years (54 to 107), in order to study eight right and 12 left hips. The capsule was approached by sequential dissection, the identification of intermuscular planes and the reflection of the individual muscles. Posteriorly, gluteus maximus was elevated and reflected medially, retaining its attachments to the medial aspect of the iliac crest and sacrum but severing the neurovascular bundle. The short external rotators and quadratus femoris were then identified, along with the sciatic nerve, and detached from the greater trochanter. Gluteus medius and minimus were detached separately from their insertions to the greater trochanter. Anteriorly, the femoral triangle was identified and the femoral nerve carefully exposed. Tensor fascia lata, sartorius, rectus femoris and vastus lateralis were mobilised and reflected from distal to proximal, exposing iliopsoas, which was detached from the lesser trochanter and gently separated from the anterior aspect of the capsule to provide better exposure. Medially, adductor longus and pectineus were dissected off the pubis and reflected medially from distal to proximal to expose the divisions of the obturator nerve arising through obturator externus and crossing adductor brevis. Adductor brevis was detached medially and reflected laterally. The individual nerves and their branches were identified macroscopically near their levels of origin in the pelvis and thigh, and traced towards their points of termination in the joint capsule.

We chose to illustrate this arrangement by depicting the capsule as the face of a clock. The reference point from which measurements...
were taken was the inferior acetabular notch to depict the six o’clock position. Therefore, the position between 12 and six o’clock represented the anterior aspect of the capsule and that between six and 12 o’clock the posterior position. Each hour represented an arc of 30˚, and our measurements, taken with a protractor, were located within an arc of 15˚ (half an hour).

**Results**

We identified seven nerves contributing to the innervation of the capsule, either directly or via muscular branches in a relatively constant pattern. The nerves, their frequency of contribution to capsular innervation, their total number, mean and range of branches, as well as the area of capsule (medial/lateral) supplied, are summarised in Table I. The

<table>
<thead>
<tr>
<th>Nerve</th>
<th>Mean contribution to capsular innervation (%)</th>
<th>Number of capsular branches in 20 hips</th>
<th>Aspect of capsule supplied (number of branches/total number of branches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral</td>
<td>95</td>
<td>30</td>
<td>Total: 15/30; Mean: 1.5; Range: 0 to 3; Medial: 16/30; Lateral: 14/30</td>
</tr>
<tr>
<td>Obturator</td>
<td>85</td>
<td>31</td>
<td>Total: 1/31; Mean: 0.1; Range: 0 to 7; Medial: 30/31; Lateral: 1/31</td>
</tr>
<tr>
<td>Accessory obturator</td>
<td>5</td>
<td>2</td>
<td>Total: 0/2; Mean: 0.1; Range: 0 to 2; Medial: 3/26; Lateral: 0/2</td>
</tr>
<tr>
<td>Superior gluteal</td>
<td>85</td>
<td>26</td>
<td>Total: 13/26; Mean: 1.3; Range: 0 to 4; Medial: 38/52; Lateral: 14/52</td>
</tr>
<tr>
<td>Sciatic nerve</td>
<td>80</td>
<td>52</td>
<td>Total: 2.6; Mean: 0.1; Range: 0 to 4; Medial: 27/33; Lateral: 6/33</td>
</tr>
<tr>
<td>Nerve to quadratus femoris</td>
<td>100</td>
<td>33</td>
<td>Total: 1.65; Mean: 1; Range: 1 to 4; Medial: 0/4; Lateral: 4/4</td>
</tr>
<tr>
<td>Inferior gluteal</td>
<td>10</td>
<td>4</td>
<td>Total: 0.2; Mean: 0; Range: 0 to 4; Medial: 0/4; Lateral: 4/4</td>
</tr>
</tbody>
</table>

Illustration of the pattern of capsular innervation as a radial graph, demonstrating the total number of branches from each of the main nerve trunks at each orientation on the clock face (the further away from the centre, the greater the number of branches at that particular orientation).
The anatomy of the hip joint capsule is well known and described, but less information is available regarding capsular innervation and its pattern. Most attempts to describe capsular innervation appear to have taken place in the mid to late 19th and early 20th centuries. Reports were inconsistent, variable, and, at times, based on isolated dissections of single specimens, thereby not accounting for anatomical variations. The capsule is generally thought to receive its innervation from branches of the obturator, femoral, sciatic and superior gluteal nerves, as well as from the nerve to quadratus femoris and possibly from the accessory obturator nerve, which is present in between 10% and 30% of people. There has been considerable difference of opinion as to whether the inferior gluteal nerve contributes to capsular innervation. Recently, Birnbaum et al attempted to elucidate this further, examining 11 formalin-mounted human hips. They described a vague separation between the anterior (obturator and femoral nerve) and posterior (sciatic nerve, superior gluteal nerve and nerve to quadratus femoris) sensory innervations of the capsule.

We further explored the innervation of the capsule to define its pattern more accurately. Our findings are consistent with previous reports, and demonstrate a richly innervated structure with a concentration of nerve fibres in the anteromedial region. We found that the capsule is innervated by five to seven nerves and a variable number of their branches (direct or muscular), with each nerve supplying the general region. There was a fairly constant distribution within each region with some overlap between adjacent nerve territories. The accessory obturator nerve was found in only 5% of our specimens, a lower incidence than in previous reports. This is most likely to be a result of anatomical variation, although some authors have pointed out the difficulty of discriminating between motor fibres to the iliacus muscle and capsular branches, as well as between the accessory femoral and obturator nerves. We opted to describe arcs of 15°, as we felt a smaller arc, while more accurate, would not be realistically transferable to a surgical procedure. Although our study was limited to 20 specimens and there is an existing propensity to anatomical variation, the anterosuperior area of the hip capsule appears poorly innervated. In our study a true, internervous safe zone existed anterosuperiorly between one o’clock and half past two, representing an arc of 45°.

While there have been many changes in implant designs and biomaterials, surgical approaches have remained relatively unchanged over time. A variety of approaches to the proximal femur and acetabulum have been described and modified. Once the capsule is reached, it is opened by various incisions or is excised. A review of the literature suggests that these are performed at varying locations and to varying extents. Some of the original descriptions of the approaches fail to indicate the precise site or extent of the capsulotomy/capsulectomy, or have since been modified. The capsular aspect of the approach is generally left to the

![Pie chart summarising findings of the radial graph, illustrating the internervous safe zone anterosuperiorly.](image)
discretion of the individual surgeon, with consideration
given to the diagnosis and the pre-operative characteristics
of the patient, including contractures, range of movement,
neuromuscular compromise, and the need to gain accept-
able exposure.

Small-incision or ‘minimally-invasive’ approaches to
total hip replacement (THR) have been advocated by
some orthopaedic surgeons.13-15 Single mini-incision hip
replacement has recently been approved by the National
Institute for Health and Clinical Excellence (NICE).16 By
minimising surrounding tissue trauma, the intention is not
only to improve the cosmetic appearance of the scar, but,
more importantly, to decrease blood loss and early post-
operative pain, as well as to facilitate and accelerate
recovery. Whether this improves the functional outcome
remains to be seen. These tissue-preserving operations can
be performed through a single smaller incision, with a
conventional approach or modified deeper dissection (less
muscle and tendon transection), or two/three mini-
incisions. Several main methods have been described to
date, with variable capsular dissection, excision or
release.13-15

The concept of soft-tissue internervous safe zones is not
new. Kocher’s original incisions through the muscular
layers were designed to pass between adjacent nerve terri-
tories, although this was not extended to the capsule.10
Most of the literature9-12 on both traditional and
minimally-invasive exposures describes the intermuscular
nervous safe zones around the hip, but again fails to
extrapolate this to the capsule. Other studies have
described nervous safe zones within gluteus medius in an
attempt to reduce the risk of damage to its innervation,
and thereby improve functional outcome, during intra-
muscular incisions in the (antero)lateral approach.17,18
The overall pattern of capsular innervation, however, sug-
gests that there is an internervous safe zone, where a
‘minimally-invasive’ capsular incision is possible and the
risk of nerve damage is lowest. This area is located antero-
superiorly and can be used during approaches to the hip
capsule. With the anterior approach, the internervous
planes are developed between the femoral and gluteal
nerves before reaching the capsule between approximately
one and three o’clock, enabling incision of the capsule in
the proposed safe arc of 45˚ between one o’clock and half
past two. In the anterolateral and lateral approaches,
there is no true internervous zone during the more super-
ficial dissections, although once the capsule is reached
between 11 and two o’clock, the capsulotomy could be
safely performed in the safe zone mentioned in the ante-
rior approach. However, with the posterior approach,
which would typically reach the capsule between eight
and ten o’clock, the capsule is richly innervated with no
safe zone. Similarly, during hip arthroscopy the anterior
and anterolateral portals could be placed within the safe
zone.

In a prospective study by Majewski et al., balance during
everyday gait and sit-to-stand tasks was shown to be impaired
by osteoarthritis (OA) of the hip, but able to be almost fully
restored following THR. Proprioceptors at the hip joint are
known to exist not only in the capsule, but also in the ligamen-
tum teres, the labrum, the transverse acetabular ligament as
well as the extracapsular elements – muscle fibres and ten-
dons. Additionally, it is thought that the capsular nerves are
modified qualitatively rather than quantitatively by adjacent
disease processes, such as OA, initially undergoing focal or
segmental thickening of the peri- and endoneurium, and
finally undergoing complete fibrous transformation. Therefore,
our results might have greater implications in younger
patients or in those with a more acute disease process.

The principal limitation of our study is that it was anatom-
ical rather than functional. As a result, the question of whether
performing the capsular incisions in our recommended safe
zone will improve functional and symptomatic outcome has
not been examined. The capsule is still poorly understood, but
its importance is gradually being appreciated.

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