Parsons' knob, the bony landmark of the tibial insertion of the anterior cruciate ligament, evaluated by three-dimensional computed tomography

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Abstract

Background: In recent years, highly detailed evaluations have been performed using three-dimensional computed tomography (3D CT). Very small bony ridges, such as Resident's ridge and the lateral bifurcate ridge can be visualised by 3D CT. The purpose of this study was to ascertain whether Parsons' knob, which was recognised as the bony landmark of the anterior cruciate ligament insertion on the tibia, can be visualised by 3D CT, and, if this is possible, to clarify its location and morphology.

Methods: One hundred knees were scanned by CT in this study and 3D models were created using the volume-rendering technique. Parsons' knob was detected on the axial 3D CT view of the tibial plateau. The location of the knob was presented on a grid aligned with the medial-to-lateral and anterior-to-posterior anatomical tibial axes. All measurements were expressed as a percentage of the corresponding maximum dimension. The width and height of Parsons' knob were also measured.

Results: Parsons' knob was detected in all 100 knees and was ordinarily found as a ridge that ran obliquely forward from the anterior edge of the medial spine. The knob was located at an average of 22 ± 3.1% of the anterior-to-posterior tibial plateau depth from the anterior edge of the tibia and extended from a mean ± s.d. of 46.9 ± 2.1% to 54 ± 3.6% of the medial-to-lateral tibial plateau width from the medial edge of the tibia. The average width of the knob was 11.5 ± 3.1 mm, and the average height was 1.2 ± 0.3 mm at the most medial portion, 0.2 ± 0.3 mm at the most lateral portion, and 1.2 ± 0.3 mm at the intermediate portion between them. The medial and intermediate portions of the knob were significantly higher than the lateral portion (p < 0.05).

Conclusion: The location and morphology of Parsons' knob can be well-visualised using 3D CT.

Keywords: anterior cruciate ligament; bony landmark; reconstruction; three-dimensional computed tomography; tibial insertion

Introduction

In recent years, several anatomical studies of the anterior cruciate ligament (ACL) have been reported. In particular, several detailed reports on Resident's ridge, an osseous landmark in the ACL femoral attachment, have been published.1–4 Resident's ridge is a thick ridge on the medial wall of the lateral femoral condyle that runs through the entire ACL footprint from proximal to distal. Moreover, a “lateral bifurcate ridge” that runs between the femoral attachment of the anteromedial (AM) and posterolateral bundles has also been reported.5 These ridges are important and useful bony landmarks for anatomical femoral tunnel drilling in arthroscopic ACL reconstruction. Some reports on anatomical ACL reconstruction describe the use of Resident's ridge in the

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femur to verify the drilling location when creating femoral tunnels. Many good to excellent postoperative clinical results of anatomical ACL reconstruction have been reported. However, there are few reports concerning bony landmarks that help to create anatomical tibial tunnels.

In 1906, Parsons reported that the tibial attachment of the ACL is indicated by a small knob on the outer margin of the internal articular facet and that this attachment runs transversely outward to about the mid-sagittal line of the tibia. This small knob was subsequently named Parsons' knob and was recognised as the bony landmark of the ACL insertion on the tibia. However, only 10% of cases showed radiological evidence of Parsons' knob.

In recent years, highly detailed evaluations have been performed using three-dimensional computed tomography (3D CT). Very small bony ridges, such as Resident's ridge and the lateral bifurcate ridge can be visualised by 3D CT. Hence, the hypothesis of the present study was that Parsons' knob can also be visualised by 3D CT. Therefore, the purpose of this study was to ascertain whether Parsons' knob can be visualised by 3D CT, and, if this was possible, to clarify its location and morphology.

Materials and methods

Approval for this study was obtained from the ethics committee of our institution, and written informed consent was obtained from each patient.

One hundred knees were scanned by CT in this study. There were 48 male and 52 female patients, and the mean patient age was 39 years (range, 15–57 years). Patients with knee injuries such as ACL rupture, periarticular fracture, and knee contusion underwent preoperative CT evaluation from April 2009 to December 2010. Patients were excluded if they had over Grade 2 degenerative arthritis by the Kellgren and Lawrence classification.

Two-dimensional CT was performed with a multislice system (Aquilion CX Edition; Toshiba Medical Systems, Tochigi, Japan). Scan parameters were as follows: 120 kVp and 200 mA, matrices of 512 × 512, gantry tilt of 0°, slice thickness of 0.5 mm, and beam pitch of 0.5 second gantry rotation. The two-dimensional images were then reconstructed for a 180 mm field of view with a 2.0 mm retrospective slice thickness to obtain 300–350 slices. After CT, 3D CT models were created using the volume-rendering technique (ZIO software; ZIO Japan, Tokyo, Japan). The 3D shaded volume-rendering (SVR) images were reconstituted using the ZIOSTATION version 1.3.x workstation (AMIN, Inc., Tokyo, Japan).

Identification of Parsons' knob

After the reconstruction of the knee bone model, the femur and patella were selected for removal, and the tibial articular surface was viewed from straight above to obtain a true proximal-to-distal view of the tibial plateau. Next, the tibia was horizontally and uniaxially rotated to obtain a true frontal view of the tibia. The medial intercondylar ridge, medial tibial spine, and Parsons' knob were identified on these views (Fig. 1).

Location of Parsons' knob

After identifying Parsons' knob, its location was presented in a grid anatomically aligned with the medial-to-lateral and
anterior-to-posterior anatomical tibial axes, as previously
described. In a true proximal-to-distal view of the tibial
plateau, the medial-to-lateral anatomical tibial axis was
defined by the line between the most posterior margin of the
medial tibial condyle and the lateral tibial condyle, and
anterior-to-posterior anatomical tibial axis was defined by the
line perpendicular to the line between the most posterior
margin of the lateral tibial condyle and the medial tibial
condyle. The anterior-to-posterior and medial-to-lateral pos-
tions of Parsons’ knob were determined with the use of a true
proximal-to-distal view of the tibial plateau (Fig. 2).

Tibial anterior-to-posterior measurements were made from
the line (A) running through the anterior border of the tibial
plateau (where the plateau edge drops down to the shaft) to
the line (P) running through the most posterior border of the
tibial plateau. Medial-to-lateral measurements were made
from the line (M) running through the medial border of the
tibial plateau to the line (L) running through the lateral border
of the tibial plateau (Fig. 2). The length from line A to Par-
sons’ knob (a) was measured (Fig. 2). The length from line M
to the most medial edge of Parsons’ knob (b) and the length
from line M to the medial border of the tibial plateau to the
most lateral edge of Parsons’ knob (b’) were also measured
(Fig. 2).

The location of Parsons’ knob was expressed as a per-
centage. The anterior-to-posterior position was calculated as the
percentage of the length from line A to line P [(A–P): a/A–P (%)], and the medial-to-lateral position was calculated as the
percentage of the length from line M to line L [(M–L): b/M–L or b’/M–L (%), respectively].

**Morphology of Parsons’ knob**

The length of Parsons’ knob was measured as b’–b (mm)
(Fig. 2). The height of Parsons’ knob was also measured using
sagittal sections of Parsons’ knob (Fig. 3). With these sections,
a base line at the bottom of the knob was drawn parallel to the
joint surface to connect the anterior and posterior edges of the
knob (Fig. 3B). A perpendicular line was drawn from the top
of the knob to the base line, and the length from the top to the
intersection of the two lines was measured. Then, the height of
the most medial portion [Fig. 3C(a)], most lateral portion
[Fig. 3C(c)], and intermediate portion between both edges was
measured [Fig. 3C(b)].

**Statistical analysis**

The height of Parsons’ knob at the most medial portion,
mmost lateral portion, and intermediate portion between them
were compared by Fisher’s protected LSD multiple compari-
son test using statistical software (StatView for Windows,
version 5.0; SAS Institute, Cary, NC, USA). The level of
significance was set at p < 0.05.

**Results**

**Identification of Parsons’ knob**

Using the reconstructed 3D CT tibial bone models, the
tibial articular surfaces were viewed from straight above and
Parsons’ knob could be identified in all 100 cases.

**Location of Parsons’ knob**

The knob was located at a mean ± standard deviation of
22 ± 3.1% of the anterior-to-posterior tibial plateau depth
from the anterior edge of the tibia. The knob ran trans-
versely from 46.9 ± 2.1% to 54 ± 3.6% of the medial-to-
lateral tibial plateau width from the medial edge of the
tibia (Table 1).

**Morphology of Parsons’ knob**

The average width of the knob was 11.5 ± 3.1 mm (range,
10.5–12.2 mm). The average height of the knob was
1.2 ± 0.3 mm (range, 0.9–1.4 mm) at the most medial portion,
0.2 ± 0.3 mm (range, 0.1–0.8 mm) at the most lateral portion,
and 1.2 ± 0.3 mm (range, 1.0–1.4 mm) at the intermediate
portion between them. Both the medial and intermediate
portions of the knob were significantly higher than the lateral
portion (p < 0.05; Table 2).

**Discussion**

The most important finding of the present study was that
Parsons’ knob, the anterior border of the tibial ACL origin,
could be visualised by 3D CT. Furthermore, the location and
morphology of the knob was clarified with 3D CT.
The ACL femoral insertion has been well reported. Some reports describe the femoral bony landmarks that help surgeons to verify the location of femoral tunnels during anatomical ACL reconstruction surgery. Shino et al. reported that Resident’s ridge, which runs from proximal to distal and anterior to posterior in the medial wall of the lateral femoral condyle, was arthroscopically identifiable on the lateral intercondylar notch wall and could be a useful bony landmark to create femoral bone tunnels. Ferretti et al. reported that they could confirm the location of the lateral intercondylar ridge and lateral bifurcate ridge, which exist between the anteromedial bundle and posterolateral bundle on CT at the ACL femoral insertion. They performed accurate anatomical ACL reconstruction surgery using these ridges as bony landmarks.

However, there are few reports on landmarks that help to create anatomical tibial tunnels. Morgan et al. reported that the ACL sagittal central insertion point on the intercondylar floor averages 7 mm (range, 7–8 mm) sagittally anterior to the anterior margin of the posterior cruciate ligament when the knee is flexed at 90°. In this way, the posterior cruciate ligament may be used as a reliable reference landmark to locate the ACL sagittal central insertion. This constant relationship was found to be independent of knee size. In their cadaveric study, Girgis et al. found a relationship between the ACL tibial insertion and the insertion of the anterior horn of the lateral meniscus. However, the anterior extent to which the tibial tunnel can be created has not been reported.

In 1906, Parsons reported that the tibial attachment of the ACL is indicated by “a little knob” on the outer margin of the internal facet. From that, the attachment runs transversely outward to about the mid-sagittal line of the tibial head. Berg reported that this knob could be a useful bony landmark for ACL reconstruction. However, only 10% of cases had

Table 1
Location of Parsons’ knob.  

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean ± standard deviation (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a/A–P (%)</td>
<td>22 ± 3.1 (18–27)</td>
</tr>
<tr>
<td>b/M–L (%)</td>
<td>46.9 ± 2.1 (43–50)</td>
</tr>
<tr>
<td>b/M–L (%)</td>
<td>54.0 ± 3.6 (50–57.5)</td>
</tr>
</tbody>
</table>

*a See Fig. 2 for explanations of markers.

Table 2
Morphology of Parsons’ knob.  

<table>
<thead>
<tr>
<th>Location</th>
<th>Mean ± standard deviation (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>11.5 ± 1.0 10.5–12.2</td>
</tr>
<tr>
<td>Height</td>
<td></td>
</tr>
<tr>
<td>Medial</td>
<td>1.2 ± 0.3  0.9–1.4</td>
</tr>
<tr>
<td>Intermediate</td>
<td>1.2 ± 0.1 * 1.0–1.4</td>
</tr>
<tr>
<td>Lateral</td>
<td>0.2 ± 0.3  0.1–0.8</td>
</tr>
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*p < 0.05.
radiological evidence of Parsons’ knob. Jacobsen22 examined 75 macerated human knee specimens and confirmed a distinct knob in 45% of cases. Pecina et al23 assessed the presence of Parsons’ knob on lateral radiographs of patients in an ACL injury group and participants in a control group. They confirmed Parsons’ knob in 32.2% of the patients and 13.3% of the participants in the control group.

Nevertheless, Parsons’ knob could be visualised and identified using 3D CT in all cases in the present study. The location of Parsons’ knob on the tibial articular surface was identified, and the length and height of the knob were measured. The medial portion of the knob was significantly higher than the lateral portion. Thus, it was possible to recognise the knob to be slope-shaped. The morphology of this bony formation might be a “ridge” rather than a “knob”.

Hara et al24 reported in their cadaveric study that Parsons’ knob runs approximately 10 mm transversely, and they confirmed that the ACL tibial insertion is located just posterior to this knob. In addition, they cut the specimens sagittally into four quarters and evaluated the height of the knob. The mean height of each quarter of the knob was 1.2 mm, 1.3 mm, 1.1 mm, and 0.3 mm from medial to lateral, respectively. These results were almost identical to the results obtained in this study.

In a recent cadaveric study, Feretti et al25 showed that the medial tibial spine demonstrated a very constant bony landmark of the ACL tibial insertion in all specimens. They also showed that the intermeniscal ligament had a constant anatomy and that it was the anterior border of the ACL. Kongcharoenombat et al26 examined the relationship between the position of the transverse ligament and the anterior edge of the ACL tibial footprint in a cadaveric study. They concluded that the percentages of the anatomic location from the anterior tibia over the maximum anterior-posterior length of the transverse ligament averaged 21.20 ± 4.1% and that the anterior edge of the ACL tibial insertion averaged 21.60 ± 4.0%. They also concluded that the transverse ligament coincides with the anterior edge of the ACL tibial footprint in the sagittal plane. The results of the present study, which showed that Parsons’ knob was located at an average of 22 ± 3.1% of the anterior-to-posterior tibial plateau depth from the anterior edge of the tibia, were almost similar to their results. Thus, the authors have to evaluate the location of the “Parsons’ knob” using arthroscopy whether Parsons’ knob could be a good bony landmark for creation of an anatomical tibial tunnel or not. Furthermore, these anatomical structures should be considered during anatomical ACL reconstruction.

There are some limitations in this study. First, it was not ascertained whether Parsons’ knob could be observed or not under arthroscopy in ACL reconstruction surgery. Second, the clinical results of ACL reconstruction, in which the anteromedial tibial tunnel was created just posterior to the knob, have not yet been evaluated.

However, the tibial tunnel locations could be evaluated on postoperative 3D CT. To perform a more accurate “anatomical” ACL reconstruction, it may be very important to evaluate the relationship between the location of the tibial tunnel on preoperative planning 3D CT and that on postoperative 3D CT, and to also evaluate the relationship between the locations of the tibial tunnel and Parsons’ knob. This information is crucial for subsequent steps of the reconstruction.

Parsons’ knob that was recognised as the bony landmark of the ACL insertion on the tibia was difficult to be recognised on lateral radiological. Nevertheless, Parsons’ knob could be visualised and identified using 3D CT in all cases in the present study. Parsons’ knob may be a useful osseous landmark for anatomical tibial tunnel drilling in arthroscopic ACL reconstruction.

Conclusion

Parsons’ knob, the anterior border of the tibial ACL origin, can be visualised by 3D CT. The location and morphology of the knob was clarified in this study.

Conflicts of interest

The authors declare that they have no competing interests.

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References


