ABSTRACT

Purpose. To evaluate histological changes and neural elements in 100 posterior cruciate ligaments (PCLs) in patients with osteoarthritis.

Methods. 100 PCLs were obtained from a consecutive series of 46 women and 16 men aged 49 to 91 (mean, 67) years who underwent primary PCL-retaining total knee replacement for osteoarthritis. Histology was examined using conventional light microscopy. The PCLs were graded histologically in terms of parallel orientation of collagen fibres, mucoid degeneration, inflammation, and haemosiderin deposition. Histological changes were graded as normal, mild degeneration, moderate degeneration, and severe degeneration. The neural elements were assessed using immunohistochemical staining for S100 protein and neurofilaments. The histopathologist was blinded to the age, gender, and clinical and radiological grades of osteoarthritis.

Results. One specimen was excluded from analysis owing to inadequate tissue. In the remaining 99 specimens, histology was normal in 72, mildly degenerative in 4, moderately degenerative in 4, and severely degenerative in 15. 76 specimens were positive for S100 protein or neurofilament or both by immunohistochemical staining, indicating the presence of neural elements.

Conclusion. Most knees with osteoarthritis present with viable PCLs. Retaining the PCL in total knee replacement is a good option for better kinematics, stability, and proprioception.

Key words: arthroplasty, replacement, knee; immunohistochemistry; osteoarthritis, knee; posterior cruciate ligament; sensory receptor cells

INTRODUCTION

Tears of the posterior cruciate ligament (PCL) without preceding trauma are uncommon, and degenerative patterns of the PCL differ from those of the anterior cruciate ligament.1 Degenerative changes of the PCL occur in later stages of osteoarthritis. Whether to retain or sacrifice the PCL during total knee replacement (TKR) is controversial.2–4 Retention of the PCL enables femoral roll back, increased flexion, prevention of posterior translation, and reducing loosening and excessive polywear by decreasing stress at the fixation surfaces.5,6 The PCL is not just a collagen tissue for structural support
but has neural elements (monoreceptors) that aid integration into the musculoskeletal system\(^6\,7\) and provide proprioception to the body by mediating knee kinesthesia and statics leading to dynamic stability.\(^8\,\text{--}\,\text{10}\) Although decrease in monoreceptors and mucoid degeneration of collagen fibres occurs with the onset of osteoarthritis,\(^11\,12\) PCL-retaining knees are reported to achieve better proprioception.\(^13\,\text{--}\,\text{14}\) However, PCL-sacrificing knees are also reported to achieve similar proprioception.\(^15\,\text{--}\,\text{16}\) This study evaluated histological changes and neural elements in 100 PCLs in patients with osteoarthritis.

**MATERIALS AND METHODS**

100 PCLs were obtained from a consecutive series of 46 women and 16 men aged 49 to 91 (mean, 67; standard deviation [SD], 11) years who underwent primary PCL-retaining TKR for osteoarthritis between January 2010 and February 2010. 89 knees had a varus deformity and 11 knees had a valgus deformity (mean, 9.9°; SD, 9.6°; range, -18°–26°). Patients with inflammatory joint disease (including rheumatoid arthritis), history of previous surgery, trauma, infection, fractures, or intra-articular injections to the affected knee joint were excluded.

After femoral and tibial resection, the PCL (10x5x5 mm) was resected near the tibial insertion, owing to the presence of higher number of monoreceptors.\(^17\) The integrity of the PCL was not compromised. The PCL was preserved in 10% buffered formaldehyde solution. A transverse cut at one-third of the PCL and a longitudinal cut through the centre were made, and the specimen was embedded in paraffin wax. Mutiple 3-μm-thick sections were cut. Two sections were stained with haematoxylin and eosin, and one section each with Alcian blue and Masson trichrome to evaluate for mucoid degeneration and collagen fibre fibrosis, respectively. Histology was examined using conventional light microscopy. The PCLs were graded histologically in terms of parallel orientation of collagen fibres, mucoid degeneration, inflammation, and haemosiderin deposition.\(^18\) Each category was evaluated on both longitudinal and cross sections, and a single score was assigned to each specimen. Histological changes of each category were graded as 0 (no change), 0.5 (minimal change), 1 (mild changes), 2 (moderate changes), or 3 (severe changes). A total score of 0 to 2 was defined as normal, 3 to 4 as mild degeneration, 5 to 8 as moderate degeneration, and 9 to 12 as severe degeneration.

The neural elements were assessed using immunohistochemical staining for S100 protein (Dako RTU FLEX IR504) and neurofilaments (Dako RTU FLEX IR607). The staining was positive if one or both the markers showed positivity. The histopathologist was blinded to the age, gender, and clinical and radiological grades of osteoarthritis.

**RESULTS**

One specimen was excluded from analysis owing to inadequate tissue. In the remaining 99 specimens, histology was normal in 72, mildly degenerative in 4, moderately degenerative in 4, and severely degenerative in 15. Of the latter, 13 were aged >75 years and 2 were aged 64 and 72 years. 78 specimens showed normal parallel orientation of the collagen fibres (Fig. 1). 74 specimens showed no evidence of mucoid degeneration. 24 specimens showed mild-to-moderate inflammation. No specimen showed haemosiderin deposition. 76 specimens were positive for S100 protein or neurofilament or both by immunohistochemical staining, indicating the presence of neural elements (Fig. 2).

At the 2-year follow-up, no patient had signs of instability or radiological loosening. The mean postoperative Knee Society Score improved to 86 (range, 78–95) from 42 (range, 38–65).

**DISCUSSION**

Osteoarthritis has multiple aetiologies; systemic factors predispose to the disease and local factors determine its distribution and severity; ageing and trauma are 2 major risk factors.\(^19\,\text{--}\,\text{20}\) Advanced osteoarthritis manifests in all joint tissues, but it is not known at which specific structure the process begins.\(^21\,\text{--}\,\text{24}\) In patients with macroscopically intact PCL, PCL-retaining TKR is advocated.\(^25\) Preservation of the PCL is important for a well-functioning TKR. This can be achieved by PCL-retaining implants or PCL-substituting implants. PCL-retaining knees have a more normal and efficient gait pattern,\(^2\,\text{--}\,\text{27}\) decreased interface stress,\(^5\,\text{--}\,\text{6}\) and improved stair ascent/descent subscores.\(^28\) Nonetheless, proponents of PCL-sacrificing TKR claim that the PCL is histologically abnormal in osteoarthritic knees.\(^29\,\text{--}\,\text{30}\)

Although histology of the PCL is altered in osteoarthritic knees, the presence of monoreceptors in the PCL (despite being decreased in number) may enhance proprioception and knee kinematics after TKR.\(^11\,\text{--}\,\text{12}\)\(^17\) In immunohistochemical analysis of mechanoreceptors in the PCL, a significant, constant pattern of innervation and a variety of monoreceptors...
are present, and thus it is desirable to preserve the PCL. However, although most PCLs have an intact neural structure, extensive mucoid degeneration and irregular fibre pattern are noted. Radiological grading of osteoarthritis matches the functional state of the PCL; therefore, PCL-retaining prosthesis should not be used in patients with osteoarthritis of greater than grade-5 severity.

The mechanical property of PCL as a physical restraint to posterior translation of the tibia is well established. The main controversy lies in the role for proprioception, which is assumed to be present in most studies. In a study of 52 TKRs, 94% of the PCLs were stable after 11 years in terms of the knee scoring system, radiography, magnetic resonance imaging, and KT-1000 testing. The 15-year survival is 90% for PCL-retaining TKR and 75% for PCL-stabilising TKR.

In our study, 73% PCLs were viable and functional, and 77% demonstrated neural elements at the time of primary TKR. The grade of osteoarthritis correlates strongly with the functional status of the PCL. At the 2-year follow-up, even the knees with a histological score of >5 were clinically and radiologically stable, with no evidence of loosening.

CONCLUSION

Most knees with osteoarthritis present with viable PCLs. Retaining the PCL in TKR is a good option for better kinematics, stability, and proprioception.

DISCLOSURE

No conflicts of interest were declared by the authors.

REFERENCES


