**A B S T R A C T**

**Objective:** To investigate the associations between patient sex, age, cause of injury, and frequency of meniscus and articular cartilage lesions seen at the time of the anterior cruciate ligament reconstruction.

**Design:** Case series.

**Setting:** University affiliated hospital, Hong Kong.

**Patients:** Medical notes and operating records of 672 Chinese patients who had received anterior cruciate ligament reconstruction between January 1997 and December 2010 were reviewed. Data concerning all knee cartilage and meniscus injuries documented at the time of surgery were analysed.

**Results:** Of the 593 patients, meniscus injuries were identified in 315 (53.1%). Patients older than 30 years were more likely to suffer from meniscal injury compared with those younger than 30 years (60% vs 51%, *P*=0.043). Longer surgical delay was observed in patients with meniscal lesions compared with those without (median, 12.3 months vs 9.1 months, *P*=0.021). Overall, 139 cartilage lesions were identified in 109 (18.4%) patients. Patients with cartilage lesions were significantly older than those without the lesions (mean, 27.6 years vs 25.1 years, *P*=0.034). Male patients were more likely to have chondral injuries than female patients (20.1% vs 10.9%, *P*=0.028). The risk of cartilage lesions was increased by nearly 3 times in the presence of meniscal tear (*P*<0.0001; odds ratio=2.7; 95% confidence interval, 1.7-4.2).

**Conclusions:** Increased age and surgical delay increased the risk of meniscal tears in patients with anterior cruciate ligament tear. Increased age, male sex, and presence of meniscal tear were associated with an increased frequency of articular lesions after an anterior cruciate ligament tear.

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**Introduction**

Anterior cruciate ligament (ACL) tear is one of the commonest sport injuries seen in clinical practice, and such injury is often associated with meniscal and chondral lesions. It is widely believed that early surgery can prevent such lesions in ACL-deficient patients, and probably help avoid the most dreadful complication of early osteoarthritis of the knee. Despite multiple studies conducted to evaluate the relationship between intra-articular injuries and ACL tear, such associations among Asians, especially Chinese, have not been extensively studied.

Data show that females are more susceptible to ACL injury than their male counterparts, but lower risk of other intra-articular injuries in females was observed in some studies. Furthermore, a study showed that the incidence of meniscus tear was associated with the mechanism of ACL injury; however, other studies were not able to show a significant relationship between the type of sports causing injury and the incidence of meniscal and chondral lesions.

The objective of this study was two-fold. Our first aim was to report the meniscal and chondral lesions that accompany ACL tears in a large Chinese population. Our second aim was to test for relationships between the aforementioned lesions and patient sex, age, surgical delay, and causes of ACL injury.

**Methods**

A database that recorded all patients who had...
received ACL reconstruction in our hospital since 1997 was reviewed. Overall, 672 Chinese patients who had received the surgery between January 1997 and December 2010 were identified. Their medical notes and operating records were reviewed. Data concerning the patient sex, age, causes of injury, elapsed time from injury to surgery, and all knee cartilage and meniscus injuries documented at the time of surgery were analysed.

Exclusion criteria were: patients who had radiological evidence of osteoarthritis (Kellgren-Lawrence grade 3 or 4); a concomitant grade III medial collateral ligament, lateral collateral ligament, or posterior cruciate ligament deficiency (evaluated and recorded by means of examination with the patient under anaesthesia at the time of surgery); any revision procedure involving the ACL; or knee dislocation.

The time of the initial ACL injury was determined from the patient’s history. This included a definite incident of a single twisting injury, with the knee giving away with a ‘pop’ sound, gross knee swelling, and inability to resume the sport or walking. The nature of this injury was further verified with the hospital medical notes, or records of the primary attending physician, when available. Patients were considered potential candidates for ACL reconstruction if any two of the following criteria were satisfied: (1) instability during pivoting movements; (2) signs of ACL deficiency, including a positive Lachman test, anterior drawer test, or a positive pivot shift test; and (3) evidence of an ACL tear on magnetic resonance imaging (MRI).

The presence of cartilage injuries and meniscal lesions was confirmed in the operating room by means of knee arthroscopy. Several independent variables were studied: patient sex, age at the time of surgery, surgical delay (defined as the duration in months between the index ACL injury and reconstruction), and causes of ACL injury.

**Statistical analyses**

Data analysis was performed using the Statistical Package for the Social Sciences (Windows version 15.0; SPSS Inc, Chicago [IL], US). Student’s *t* test was used to compare the means of the age. Mann-Whitney *U* test was used to compare the means of the length of surgical delay. Fisher’s exact test was used to evaluate the categorical variables. Binary logistic regression was used to calculate the independent effects of individual factors. A *P* value of <0.05 was considered to be statistically significant.

**Results**

Of 672 patients who received ACL reconstruction, 79 were excluded (7 with concomitant high-grade ligament deficiency, and 72 with revision ACL surgery) and 593 patients were considered for analysis. These included 483 (81%) males and 110 (19%) females. There were 297 (50%) right and 296 (50%) left knees. Their mean age at the time of surgery was 26 years (range, 13-51 years), and their median length of surgical delay was 10.5 months (range, 0.4-241.8 months).

Most of the patients had had their injuries during sports activities (89.5%), with soccer (n=226, 42.6%) and basketball (n=163, 30.7%) being the two most common sports (Tables 1 and 2). The age distribution of patients having meniscal and cartilage injuries is shown in Table 3. The incidence of intra-articular lesions in different sports activities leading to injury is shown in Table 4.

Meniscus injuries were identified in 315 (53.1%) patients. There were 146 (24.6%) isolated lateral tears, 123 (20.7%) isolated medial tears, and 72 with revision ACL surgery. Of 672 patients who received ACL reconstruction, 79 were excluded (7 with concomitant high-grade ligament deficiency, and 72 with revision ACL surgery) and 593 patients were considered for analysis. These included 483 (81%) males and 110 (19%) females. There were 297 (50%) right and 296 (50%) left knees. Their mean age at the time of surgery was 26 years (range, 13-51 years), and their median length of surgical delay was 10.5 months (range, 0.4-241.8 months).

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Meniscus injuries were identified in 315 (53.1%) patients. There were 146 (24.6%) isolated lateral tears, 123 (20.7%) isolated medial tears, and 46 (7.8%) bilateral tears.

Patients older than 30 years were more likely to suffer from meniscal injury versus those younger than 30 years (60% vs 51%; *P*=0.043 by Fisher’s exact test). Longer surgical delay was observed in patients with meniscal lesions versus those without such lesions (median, 12.3 months vs 9.1 months; *P*=0.021 by Mann-Whitney *U* test). Also, patients with medial meniscal tear had a longer surgical delay than those with lateral meniscal tear (median, 16.7 months vs 9.0 months; *P*<0.001, Mann-Whitney *U* test).
However, no significant associations were observed between sex, causes of injury, type of sports, and presence of meniscal lesions.

Overall, 139 cartilage lesions were identified in 109 (18.4%) patients. There were 16 patella (11.5%) lesions, 92 (66.2%) femoral condyle lesions, and 31 (22.3%) tibial plateau lesions. Patients with cartilage lesions were significantly older than those without the lesions (mean, 27.6 years vs 25.1 years; \( P=0.034 \) by Student’s \( t \) test). Female patients were less likely to suffer from chondral injuries than male patients (10.9% vs 20.1%; \( P=0.028 \) by Fisher’s exact test). Female sex was found to be independently associated with incidence of cartilage injury in binary logistic regression (\( P=0.029; \) odds ratio [OR]=0.475; 95% confidence interval [CI], 0.243-0.929) [Table 5]. Presence of meniscal tear was associated with a 3-fold increased risk of cartilage lesions (\( P<0.001 \) by Fisher’s exact test; OR=2.7, 95% CI, 1.7-4.2).

No significant association, however, was found between surgical delay, causes of injury, type of sports, and cartilage lesions.

**Discussion**

Our study showed that longer surgical delay was present in patients with meniscal lesions, a finding that concurs with data from other published literature. Although Slauterbeck et al., Piasecki et al., and O’Connor et al. reported that female patients had a lower rate of meniscus injury than male patients, such association was not observed in our study which recruited a lower proportion of female patients; similar observation was made in the study by Murrell et al.

It is postulated that in acute ACL injury, excessive anterolateral rotation of the tibia on the femur traps the lateral meniscus between the posterolateral aspect of the tibial plateau and the central portion of the lateral femoral condyle. The lateral meniscus is susceptible to a tear when the tibia reduces. However, the scenario is different in patients with chronic ACL deficiency. Recurrent anterior translation of tibia on the femur results in increased stress on the more stably fixed medial meniscus due to the coronary ligaments, leading to a subsequent medial meniscal tear. Our study found that ACL-deficient patients with medial meniscus

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<th>TABLE 1. Causes of injury</th>
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<td>No. (%) of patients</td>
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<td>Sports</td>
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<td>Activity of daily living</td>
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<td>Work injury</td>
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<td>Road traffic accident</td>
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<td>Miscellaneous</td>
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<th>TABLE 2. Type of sports activity causing anterior cruciate ligament tear</th>
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<td>No. (%) of patients</td>
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<tr>
<td>Soccer</td>
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<td>Basketball</td>
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<td>Taekwondo</td>
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<td>Snow sports</td>
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<td>Rugby</td>
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<td>Miscellaneous</td>
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<th>TABLE 3. Age distribution of patients who had meniscal and cartilage injuries</th>
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<td>No. (%) of patients</td>
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<tr>
<td>Age-group (years)</td>
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<tr>
<td>≤20</td>
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<tr>
<td>21-30</td>
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<td>31-40</td>
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<td>≥41</td>
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<th>TABLE 4. The incidence of intra-articular lesions in different sports activities leading to injury</th>
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<tr>
<td>No. (%) of patients</td>
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<tr>
<td>Soccer (n=226)</td>
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<tr>
<td>Meniscal tear</td>
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<tr>
<td>Lateral</td>
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<td>Medial</td>
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<tr>
<td>Both</td>
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<tr>
<td>Cartilage injury*</td>
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<tr>
<td>Patella</td>
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<td>Femoral</td>
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<td>Tibial</td>
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* Some patients might have more than one cartilage lesions

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<th>TABLE 5. Binary logistic regression for the factors associated with risk of cartilage injury</th>
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<td>Variable</td>
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<tr>
<td>Female sex</td>
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<td>Age</td>
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<td>Surgical delay</td>
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tively sedentary. Paul et al6 reported an association disabled by an ACL injury than those who are rela-
participate in vigorous physical activities are more

statistical associations, however, were found between
injuries accompanying ACL tears. Granan et al13
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among amateur athletes. So far, there has been little
basketball, but such associations were not observed
injuries to the medial femoral condyle while playing
soccer) and a reduced number of intra-articular
found to have fewer meniscal tears (while playing
articular cartilage defects during knee arthroscopy,
large-scale retrospective studies which reviewed the
chondral lesions in ACL-deficient patients. In a study
by Piasecki et al,8 female high-school athletes were
found to have fewer meniscal tears (while playing soccer) and a reduced number of intra-articular
injuries to the medial femoral condyle while playing basketball, but such associations were not observed
among amateur athletes. So far, there has been little
research on sex differences in articular cartilage
injuries accompanying ACL tears. Granan et al13
reported that cartilage lesions were nearly twice as
frequent if there was a meniscal tear, and similar
observations were found in our study.

The association of age with meniscus tear and
cartilage injury with intact ACL is less extensively
studied. In a cross-sectional MRI study of nearly
1000 individuals from the general population who
were aged 50 to 90 years, 31% of knees were found
to have a meniscal tear and the incidence increased
with age. It was shown that 21% of the 50- to
59-year-old subjects had a meniscal tear, compared
to 46% of subjects aged 70 to 90 years.14 In several
large-scale retrospective studies which reviewed the
articular cartilage defects during knee arthroscopy,
the incidence of isolated chondral lesions without
associated intra- and extra-articular knee lesions
ranged from 30% to 36.6%.15-18 No significant
statistical associations, however, were found between
age and the cartilage lesions.

Studies have shown that individuals who participate in vigorous physical activities are more
disabled by an ACL injury than those who are rela-
tively sedentary. Paul et al6 reported an association
between the mechanism of an ACL injury (jumping
and non-jumping) and the incidence of concomitant
meniscus injuries, but other authors failed to show
such associations. In our study, since more than half
of the patients were injured while playing soccer or
basketball, an analysis was performed to evaluate
if the soccer and basketball players suffered from
lesions that were different from those sustained
from other causes or during other sports activities.
However, type of sports was not associated with
any of the parameters we studied. A larger sample
including patients with other causes of injury will be
needed to prove if there are differences among other
sports activities.

Another limitation of this study was that
patients receiving conservative treatment for their
ACL injury were not recruited in the present study.
This could lead to potential bias as their risks of
meniscal and articular injuries could not be estimated.
We are also aware that more sophisticated systems
to evaluate the meniscal and chondral lesions, eg the
Cooper's classification19 and the ICRS (International
Cartilage Repair Society) classification system,20
could be used to map the lesions, so as to provide
more precise anatomical description and details of
the lesions.

Compared with other studies, which report
surgical delay ranging from 1.2 to 13 months,5-7,9-11
patients in our series had a longer surgical delay.
Patients may have postponed the waiting time for
surgery or imaging including MRI. It was unclear if
patients would suffer from repeated knee injuries,
or the activities in which the patients were involved
before the surgery would have any effect over the
findings of our study.

Currently, there is intense debate concerning
the optimal timing for ACL reconstruction.21,22
Different surgeons have different personal preferences.
Some prefer early surgery while others are in favour
of an optimal period of rehabilitation before
considering surgery. Frobell et al23 concluded in his
randomised controlled trial that “In young, active
adults with acute ACL tears, a strategy of rehabilitation
plus early ACL reconstruction was not superior to a
strategy of rehabilitation plus optional delayed ACL
reconstruction.” According to Richmond et al,22
however, Frobell's conclusion is flawed; they believe
that prompt operative intervention reduces long-
term osteoarthritis after knee ACL tear. No matter
what approach the surgeons prefer, our patients with
ACL tear should be well informed about the risks
and benefits of conservative management versus
surgical reconstruction, so they can make their best
decision with the best information on hand.

Conclusions
Increased age and surgical delay were associated
with meniscal tear in patients with ACL tear, and
longer surgical delay was observed in patients with
medial meniscal tear. Increased age, male sex, and
presence of meniscal tear were all associated with
chondral lesions after an ACL tear. Cause of injury
or type of sports activity leading to ACL injury was
not associated with intra-articular lesions.
References


