

Chinese Ethnicity Is Associated With Concomitant Cartilage Injuries in Anterior Cruciate Ligament Tears

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Background: Chinese ethnicity is associated with the presence of knee osteoarthritis. This raises the possibility that it may similarly be associated with concomitant meniscus and cartilage injuries in patients with anterior cruciate ligament (ACL) tears. There are currently no published data on the effect of Chinese ethnicity in this regard.

Purpose: The primary aim was to determine whether Chinese ethnicity is associated with concomitant intra-articular injuries in patients with ACL tears and to verify the correlation of age, sex, body mass index, mechanism of injury, cause of injury, and presence of bone contusions on magnetic resonance imaging with such injuries. A secondary purpose was to determine the optimal time frame for surgical reconstruction in patients with identified risk factors for concomitant injuries.

Study Design: Cohort study; Level of evidence, 3.

Methods: The medical records of 696 patients from a multiethnic population who underwent ACL reconstruction from January 2013 to August 2016 were retrospectively analyzed. Univariate and multivariate logistic regression analyses were performed to identify patient factors that were associated with medial meniscus tears, lateral meniscus tears, and cartilage injuries. Further univariate analysis was conducted to determine the earliest time point for surgery, after which the rate of concomitant injuries was significantly higher.

Results: Over half (69.1%, $n = 481$) of our study population sustained at least 1 other concomitant knee injury. Meniscus tears were most frequently associated with ACL tears (24.1% medial, 25.6% lateral, and 15.5% medial and lateral meniscus tears). Cartilage injuries were present in 18.4% of our cohort. Chinese ethnicity was associated with concomitant cartilage injuries. Increased age (≥ 30 years) was significantly associated with cartilage injuries and male sex with medial and lateral meniscus tears. Among patients with these factors, significantly fewer medial meniscus tears and cartilage injuries were noted when surgery was carried out within 12 months of the index trauma.

Conclusion: This is one of the first studies to have identified an association between Chinese ethnicity and concomitant cartilage injuries in ACL tears. This study also found an association between increased age and an increased prevalence of cartilage injuries. Male sex was associated with both medial and lateral meniscus tears. Definitive surgery should be performed within 12 months of the index injury to minimize further intra-articular injuries.

Keywords: anterior cruciate ligament; ethnicity; risk factors; meniscus tears; cartilage lesions

Anterior cruciate ligament (ACL) tears are one of the most frequently seen orthopaedic knee injuries in clinical practice.²³ They are often associated with meniscus and cartilage lesions in the knee. Estimated rates of associated meniscus tears range from 35% to 53.1%,^{11,15,17} and cartilage injuries range from 16.5% to 28%.^{1,11,15} The long-term sequelae of an ACL tear is early osteoarthritis of the knee,^{2,16} with an even greater risk if associated with a

meniscus injury.²⁰ Quality of life is often affected to a large extent, with pain and disability accompanying an osteoarthritic knee.¹⁸

Concomitant intra-articular injuries have been found to increase in incidence with greater chronicity of an ACL tear.^{11,13,27} Surgery is often performed to restore the mechanics of the knee and to curtail the increased mechanical stress on menisci and cartilage surfaces in an ACL-deficient knee.^{4,28} The main goals are to prevent secondary injuries, maximize positive long-term outcomes, and enable patients to return to their premorbid function as much as possible.

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Several studies have examined factors associated with intra-articular injuries in ACL-deficient patients.[§] Well-documented associations include older age,^{3,6,7,10,14,19,27} male sex,^{7,10,14,19} elevated body mass index (BMI),^{3,6,7,14} and increased duration of time from injury to surgery,^{5,7,9,12,19,21,27} although the results have been inconsistent between various studies. However, ethnic predisposition has not been reported previously.

Chinese ethnicity is associated with the presence of knee osteoarthritis. For instance, the prevalence of both radiographic and symptomatic knee osteoarthritis in Chinese women in the Beijing Osteoarthritis Study was significantly higher than that in white women in the Framingham Study.³² This raises the possibility that Chinese ethnicity may similarly be associated with the presence of meniscus tears or cartilage injuries in ACL-deficient knees. Singapore's population has a Chinese majority as well as a significant non-Chinese minority. This makes it a suitable location to compare the rates of concomitant intra-articular injuries in ACL-injured patients of Chinese and non-Chinese ethnicity.

The purpose of this study was 2-fold. First, we determined if Chinese ethnicity is associated with concomitant intra-articular injuries in our cohort of patients with ACL tears. We also evaluated whether age, sex, BMI, mechanism of injury, cause of injury, and presence of bone contusions on magnetic resonance imaging (MRI) were associated with these injuries. Second, we determined the optimal time frame for surgical reconstruction in patients with identified risk factors for concomitant injuries. Our hypothesis was that Chinese ethnicity would be associated with the presence of concomitant intra-articular injuries.

METHODS

This was a retrospective study conducted at a large tertiary public hospital. We identified patients who underwent arthroscopic primary ACL reconstruction surgery from January 2013 to August 2016. Patients who registered in our ACL reconstruction registry and sustained an ACL tear with or without concomitant meniscus and cartilage injuries were eligible for the study. We excluded patients who underwent revision ACL reconstruction and those with multiligamentous injuries. All arthroscopic surgical procedures were performed by a team of fellowship-trained knee surgeons.

Relevant clinical information was extracted from the electronic medical records and registry data. This included patient characteristics such as ethnicity, age, sex, and BMI.

Ethnicity was broadly categorized into Chinese, Malay, Indian, and "other" in consensus with the main ethnic groups in Singapore.²⁵ "Other" comprised various ethnicities such as white, Arab, Vietnamese, and other Southeast Asian ethnicities and mainly included nonresident patients. In patients with a background of multiple ethnicities, the predominant ethnic group was recorded. The Chinese formed the largest ethnic group (74.3%), followed by the Malays (13.4%), the Indians (9.1%), and other ethnicities (3.2%).²⁵

Details of the ACL injury, including the date of injury, mechanism of injury, cause of injury, time to definitive surgery, and presence or absence of bone contusions on either the femoral condyles or tibial plateau on preoperative MRI, were noted as well. Bone contusions on the patella and femoral trochlea were not recorded, as these are not typically associated with an ACL injury.²⁹

All concomitant meniscus and cartilage injuries were identified on diagnostic arthroscopic surgery. Intraoperative arthroscopic findings were traced using the institution's operative theater record system. The concomitant injuries that were routinely identified for each intraoperative report were as follows: medial meniscus tear; lateral meniscus tear; and cartilage injuries of the medial femoral condyle, lateral femoral condyle, femoral trochlea, medial tibial plateau, lateral tibial plateau, and patella. Results were recorded as the presence or absence of each abnormal finding. Concomitant injuries were not recorded based on MRI findings, as results would have been subject to interobserver variability.

Statistical Analysis

All data were compiled in Excel 2003 (Microsoft Corp), and statistical analysis was performed using Statistical Package for the Social Sciences version 23.0 (SPSS Inc). Categorical variables are represented in percentages and continuous variables as mean \pm SD or median (range).

Univariate analysis using the chi-square test was performed to assess the association between the prevalence of meniscus and cartilage injuries with ethnicity, age, sex, BMI, time to definitive surgery, mechanism of injury, cause of injury, and presence of bone contusions on MRI as discrete variables. Multivariate logistic regression analysis was similarly performed to identify associated factors for medial meniscus tears, lateral meniscus tears, and cartilage injuries while adjusting for possible confounders. The odds ratio for each factor was calculated. The level of significance was set as $P < .05$.

For the purposes of analysis, ethnicity was categorized into Chinese and non-Chinese, as Chinese ethnicity was identified as a potential associated factor, given the results

[§]References 3, 6, 7, 9, 10, 12, 14, 19, 21, 27.

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Ethical approval for this study was obtained from the National Healthcare Group Domain Specific Review Board, Singapore (reference No. 2016/01003).

TABLE 1
Patient Demographics and Preoperative Characteristics^a

	Total (N = 696)	Chinese (n = 358)	Non-Chinese (n = 338)
Age, mean ± SD (range), y	25.7 ± 7.2 (14-60)	24.7 ± 6.5 (14-60)	26.8 ± 7.7 (15-55)
Sex			
Male	565 (81.2)	269 (75.1)	296 (87.6)
Female	131 (18.8)	89 (24.9)	42 (12.4)
Body mass index, mean ± SD (range), kg/m ²	24.3 ± 4.0 (13.6-42.9)	23.8 ± 3.8 (13.6-37.2)	24.9 ± 4.0 (16.5-42.9)
Obese (≥30 kg/m ²)	62 (8.9)	22 (6.1)	40 (11.8)
Overweight (≥25-29 kg/m ²)	172 (24.7)	83 (23.2)	89 (26.3)
Not overweight (<25 kg/m ²)	395 (56.8)	224 (62.6)	171 (50.6)
Missing information	67 (9.6)	29 (8.1)	38 (11.2)
Time to surgery, mean ± SD (range), mo	1.1 ± 2.2 (0.01-20.4)	1.1 ± 2.4 (0.01-20.4)	1.1 ± 2.0 (0.03-15.2)
<12 mo	488 (70.1)	261 (72.9)	227 (67.2)
≥12 mo	165 (23.7)	75 (20.9)	90 (26.6)
Missing information	43 (6.2)	22 (6.1)	21 (6.2)
Side			
Left	331 (47.6)	177 (49.4)	154 (45.6)
Right	365 (52.4)	191 (50.6)	184 (54.5)
Mechanism of injury			
Contact	164 (23.6)	84 (23.5)	80 (23.7)
Noncontact	524 (75.3)	271 (75.7)	253 (74.9)
Missing information	8 (1.1)	3 (0.8)	5 (1.5)
Cause of injury			
Sport	499 (71.7)	269 (75.1)	230 (68.0)
Military	43 (6.2)	28 (7.8)	15 (4.4)
Road traffic accident	14 (2.0)	3 (0.8)	11 (3.3)
Other	65 (9.3)	23 (6.4)	42 (12.4)
Missing information	75 (10.8)	35 (9.8)	40 (11.8)
Bone contusions on MRI			
Present	430 (61.8)	224 (62.6)	206 (60.9)
Absent	235 (33.8)	120 (33.5)	115 (34.0)
Missing information	31 (4.5)	14 (3.9)	17 (5.0)

^aData are shown as n (%) unless otherwise indicated. MRI, magnetic resonance imaging.

of the Beijing Osteoarthritis Study.³² Regarding BMI, patients were classified as obese (≥30 kg/m²) and nonobese (<30 kg/m²) based on the World Health Organization's definition of obesity in Asians.³⁰ Age was divided into 2 groups, <30 years and ≥30 years, as we found that the mean age of cohorts ranged from 23.5 to 28.6 years.^{6,9,19,27} Hence, we considered 30 years to be an appropriate age to differentiate younger and older adults. These methods of dichotomy also ensured that the numbers in each group would be suitable for statistical analysis.

The prevalence of concomitant injuries with time to definitive surgery was assessed in specific high-risk groups using the chi-square test to determine a safe cut-off time for surgical reconstruction. The durations of time were further categorized into ≥0-3, >3-6, >6-12, and >12 months. High-risk patients were defined as patients with independent associated factors for meniscus tears or cartilage injuries, identified on multivariate analysis.

RESULTS

We identified 696 consecutive patients who were eligible for the study. Table 1 summarizes the patient demographics and preoperative characteristics of the study

cohort, with a further ethnic breakdown between Chinese and non-Chinese patients. Ethnicity was distributed as 358 (51.4%) Chinese, 177 (25.4%) Malay, 85 (12.2%) Indian, and 76 (10.9%) other. The mean BMI in our study population was 24.3 ± 4.0 kg/m², and the mean duration of time from injury to definitive ACL reconstruction was 1.1 ± 2.2 years (median, 0.44 years [range, 0.01-20.4 years]).

There were 524 (75.3%) injuries caused by noncontact mechanisms such as a twisting injury or an indirect force resulting in valgus stress to the knee; 164 (23.6%) were caused by contact mechanisms, defined as a documented direct impact to the knee. The majority of patients (71.7%) sustained their injury during sporting activities. Examples of "other" causes of injury include accidental slips, falls, or trips.

In our study population, 69.1% (n = 481) of patients sustained at least 1 other concomitant knee injury. Table 2 summarizes the injury patterns and frequencies of concomitant injuries on diagnostic arthroscopic surgery, with a further ethnic breakdown. Meniscus tears were most frequently associated with ACL tears. As for cartilage injuries identified on diagnostic arthroscopic surgery, a medial femoral condyle injury (n = 75, 10.8%) was the finding of highest frequency.

TABLE 2
Concomitant Injuries on Diagnostic Arthroscopic Surgery^a

	Total (N = 696)	Chinese (n = 358)	Non-Chinese (n = 338)
≥1 concomitant injury	481 (69.1)	242 (67.6)	239 (70.7)
Meniscus tear			
≥1 location	454 (65.2)	228 (63.7)	226 (66.9)
Medial only	168 (24.1)	80 (22.3)	88 (26.0)
Lateral only	178 (25.6)	98 (27.4)	80 (23.7)
Both medial and lateral	108 (15.5)	50 (14.0)	58 (17.2)
Cartilage injury			
≥1 location	128 (18.4)	73 (20.4)	55 (16.3)
Medial femoral condyle	75 (10.8)	47 (13.1)	28 (8.3)
Lateral femoral condyle	30 (4.3)	14 (3.9)	16 (4.7)
Femoral trochlea	14 (2.0)	10 (2.8)	4 (1.2)
Medial tibial plateau	16 (2.3)	10 (2.8)	6 (1.8)
Lateral tibial plateau	24 (3.4)	14 (3.9)	10 (3.0)
Patella	30 (4.3)	18 (5.0)	12 (3.6)

^aData are shown as n (%).

Medial Meniscus Tears

Medial meniscus tears were associated with male sex on both univariate and multivariate analyses (multivariate $P = .017$). The presence of bone contusions on MRI was also associated with medial meniscus tears on univariate analysis ($P = .035$). However, its association was not statistically significant after correcting for confounding factors (Table 3). Medial meniscus tears were not associated with ethnicity, age, BMI, mechanism of injury, or cause of injury.

Lateral Meniscus Tears

Lateral meniscus tears were significantly associated with male sex on both univariate and multivariate analyses (multivariate $P = .002$) (Table 4). Lateral meniscus tears were not associated with ethnicity, age, BMI, mechanism of injury, cause of injury, or presence of bone contusions on MRI.

Cartilage Injuries

Cartilage injuries were significantly associated with patients aged ≥30 years ($P < .001$) on both univariate and multivariate analyses. Chinese ethnicity was also identified as an associated factor after correcting for confounding factors on multivariate analysis ($P = .032$) (Table 5). Further analysis showed that amongst all Chinese patients with cartilage injuries, 64.4% had lesions at the medial femoral condyle, 13.7% at the medial tibial plateau, 19.2% at the lateral femoral condyle, and 19.2% at the lateral tibial plateau compared with 50.9%, 10.9%, 29.1%, and 18.2% in non-Chinese patients with cartilage injuries, respectively. There was no statistically significant difference with respect to the location of cartilage injury. Cartilage injuries were not associated with sex, BMI, mechanism of injury, cause of injury, or presence of bone contusions on MRI.

Time to Definitive Surgery in High-Risk Groups

Table 6 shows the frequency of concomitant intra-articular injuries, categorized based on the duration of surgical delay (≥0-3, >3-6, >6-12, and >12 months) for the high-risk groups identified in the multivariate analysis. There was a statistically significant increase in the number of medial meniscus tears in male patients who had their surgery performed more than 12 months after their initial injury compared with male patients who underwent their surgery within 3 months after the injury ($P = .046$). There was no statistically significant difference in the frequency of lateral meniscus tears in male patients who had a surgical delay of ≥12 months compared with those who underwent surgical treatment earlier.

In the Chinese ethnic group, the presence of concomitant cartilage injuries was significantly higher in patients who had surgery performed more than 12 months after their initial injury compared with those who had surgery performed within 3 months after the injury ($P = .026$). However, in patients aged ≥30 years, there was no correlation between the time of surgery and the incidence of concomitant cartilage injuries.

DISCUSSION

Our hypothesis was that Chinese ethnicity would be associated with the presence of concomitant intra-articular injuries. Our findings indicate that Chinese ethnicity and increased age (≥30 years) are associated with cartilage injuries, while male sex is associated with both medial and lateral meniscus tears. Definitive reconstruction surgery should ideally be performed within 12 months of the index injury to minimize further intra-articular injuries.

Concomitant intra-articular injuries in ACL tears are important contributing factors to the development of early-onset osteoarthritis of the knee. There is evidence that early surgery can prevent the occurrence of concomitant intra-articular injuries⁸ and delay the onset of osteoarthritis of the knee.²² The identification of associated factors is thus important in determining groups of high-risk patients who would benefit from early surgery.

Within our study population, 69.1% sustained at least 1 other concomitant intra-articular knee injury, with 24.1%, 25.6%, and 15.5% sustaining medial, lateral, and bilateral meniscus tears, respectively, and 18.4% sustaining cartilage injuries. Our prevalence data are consistent with studies reporting similar patient numbers that studied factors associated with concomitant injuries.^{14,27} Klyzynski et al¹⁴ found that, of 541 patients, 36.4%, 39.0%, and 15.2% had medial meniscus tears, lateral meniscus tears, and cartilage injuries, respectively. Tandogan et al²⁷ studied 764 patients and reported a prevalence of 36.5% medial meniscus tears, 15.8% lateral meniscus tears, 20.4% bilateral meniscus tears, and 19.1% with ≥1 cartilage lesions.

Our cohort comprised 51.4% Chinese patients, 25.4% Malay patients, 12.2% Indian patients, and 10.9% patients who belonged to other ethnic groups. Our ethnic proportions were similar to those observed in a single-surgeon

TABLE 3
Univariate and Multivariate Logistic Regression Analyses for Association Between Variables and Presence of Concomitant Medial Meniscus Tears^a

	Medial Meniscus Tear, n (%)		Univariate		Multivariate	
	Present	Absent	P Value	OR (95% CI)	P Value	OR (95% CI)
Ethnicity						
Chinese	130 (36.3)	228 (63.7)	—	1.00	—	1.00
Non-Chinese	146 (43.2)	192 (56.8)	.064	1.33 (0.98-1.81)	.86	1.03 (0.72-1.48)
Age						
<30 y	200 (38.0)	327 (62.0)	—	1.00	—	1.00
≥30 y	76 (45.0)	93 (55.0)	.10	1.34 (0.94-1.90)	.50	1.16 (0.76-1.76)
Sex						
Male	239 (42.3)	326 (57.7)	—	1.00	—	1.00
Female	37 (28.2)	94 (71.8)	.003	0.54 (0.35-0.81)	.017	0.56 (0.54-0.90)
Body mass index						
Obese (≥30 kg/m ²)	31 (50.0)	31 (50.0)	—	1.00	—	1.00
Nonobese (<30 kg/m ²)	213 (37.6)	354 (62.4)	.056	0.60 (0.36-1.02)	.09	0.60 (0.34-1.08)
Mechanism of injury						
Contact	65 (39.6)	99 (60.4)	—	1.00	—	1.00
Noncontact	204 (38.9)	320 (61.1)	.86	0.97 (0.68-1.39)	.84	0.96 (0.64-1.45)
Cause of injury						
Sport	187 (37.5)	312 (62.5)	—	1.00	—	1.00
Nonsport	55 (45.1)	67 (54.9)	.12	1.37 (0.92-2.04)	.24	1.30 (0.84-2.02)
Bone contusions on MRI						
Present	158 (36.7)	272 (63.3)	—	1.00	—	1.00
Absent	106 (45.1)	129 (54.9)	.035	1.42 (1.02-1.95)	.54	1.45 (0.99-2.10)

^aBoldfaced values indicate statistical significance ($P < .05$). MRI, magnetic resonance imaging; OR, odds ratio.

TABLE 4
Univariate and Multivariate Logistic Regression Analyses for Association Between Variables and Presence of Concomitant Lateral Meniscus Tears^a

	Lateral Meniscus Tear, n (%)		Univariate		Multivariate	
	Present	Absent	P Value	OR (95% CI)	P Value	OR (95% CI)
Ethnicity						
Chinese	148 (41.3)	210 (58.7)	—	1.00	—	1.00
Non-Chinese	138 (40.8)	200 (59.2)	.89	0.98 (0.72-1.32)	.90	0.98 (0.69-1.39)
Age						
<30 y	219 (41.6)	308 (58.4)	—	1.00	—	1.00
≥30 y	67 (39.6)	102 (60.4)	.66	0.92 (0.65-1.32)	.53	0.87 (0.58-1.33)
Sex						
Male	244 (43.2)	321 (56.8)	—	1.00	—	1.00
Female	42 (32.1)	89 (67.9)	.020	0.62 (0.42-0.93)	.002	0.48 (0.30-0.77)
Body mass index						
Obese (≥30 kg/m ²)	21 (33.9)	41 (66.1)	—	1.00	—	1.00
Nonobese (<30 kg/m ²)	240 (42.3)	327 (57.7)	.20	1.43 (0.83-2.49)	.24	1.44 (0.78-2.65)
Mechanism of injury						
Contact	63 (38.4)	101 (61.6)	—	1.00	—	1.00
Noncontact	220 (42.0)	304 (58.0)	.42	1.16 (0.81-1.66)	.80	1.05 (0.70-1.58)
Cause of injury						
Sport	210 (42.1)	289 (57.9)	—	1.00	—	1.00
Nonsport	50 (41.0)	72 (59.0)	.82	0.96 (0.64-1.43)	.69	1.09 (0.71-1.70)
Bone contusions on MRI						
Present	188 (43.7)	242 (56.3)	—	1.00	—	1.00
Absent	88 (37.4)	147 (62.6)	.12	0.77 (0.56-1.07)	.06	0.70 (0.48-1.02)

^aBoldfaced values indicate statistical significance ($P < .05$). MRI, magnetic resonance imaging; OR, odds ratio.

TABLE 5
Univariate and Multivariate Logistic Regression Analyses for Association Between Variables and Presence of Concomitant Cartilage Injuries^a

	Cartilage Injury, n (%)		Univariate		Multivariate	
	Present	Absent	P Value	OR (95% CI)	P Value	OR (95% CI)
Ethnicity						
Chinese	73 (20.4)	285 (79.6)	—	1.00	—	1.00
Non-Chinese	55 (16.3)	283 (83.7)	.16	0.76 (0.52-1.12)	.032	0.60 (0.38-0.96)
Age						
<30 y	71 (13.5)	456 (86.5)	—	1.00	—	1.00
≥30 y	57 (33.7)	112 (66.3)	<.001	3.27 (2.18-4.90)	<.001	4.22 (2.60-6.89)
Sex						
Male	107 (18.9)	458 (81.1)	—	1.00	—	1.00
Female	21 (16.0)	110 (84.0)	.44	0.82 (0.49-1.36)	.59	1.17 (0.66-2.10)
Body mass index						
Obese (≥30 kg/m ²)	15 (24.2)	47 (75.8)	—	1.00	—	1.00
Nonobese (<30 kg/m ²)	101 (17.8)	466 (82.2)	.22	0.68 (0.37-1.26)	.09	0.55 (0.27-1.11)
Mechanism of injury						
Contact	26 (15.9)	138 (84.1)	—	1.00	—	1.00
Noncontact	100 (19.1)	424 (80.9)	.35	1.25 (0.78-2.01)	.11	1.56 (0.90-2.70)
Cause of injury						
Sport	92 (18.4)	407 (81.6)	—	1.00	—	1.00
Nonsport	27 (22.1)	95 (77.9)	.35	1.26 (0.78-2.04)	.92	1.03 (0.59-1.80)
Bone contusions on MRI						
Present	78 (18.1)	352 (81.9)	—	1.00	—	1.00
Absent	44 (18.7)	191 (81.3)	.86	1.04 (0.69-1.57)	.91	0.97 (0.60-1.57)

^aBoldfaced values indicate statistical significance ($P < .05$). MRI, magnetic resonance imaging; OR, odds ratio.

TABLE 6
Time to Definitive Surgery and Association of Concomitant Intra-articular Injuries in High-Risk Groups^a

	Intra-articular Injury, n (%)		Univariate	
	Present	Absent	P Value	OR (95% CI)
Medial meniscus tears				
Male				
≥0-3 mo	52 (9.8)	87 (16.5)	—	1.00
>3-6 mo	63 (11.9)	92 (17.4)	.57	1.15 (0.72-1.83)
>6-12 mo	41 (7.8)	55 (10.4)	.41	1.25 (0.73-2.12)
>12 mo	68 (12.9)	70 (13.3)	.046	1.63 (1.01-2.62)
Lateral meniscus tears				
Male				
≥0-3 mo	58 (11.0)	81 (15.3)	—	1.00
>3-6 mo	65 (12.3)	90 (17.0)	>.99	1.01 (0.63-1.60)
>6-12 mo	35 (6.6)	61 (11.6)	.42	0.80 (0.47-1.37)
>12 mo	72 (13.6)	66 (12.5)	.082	1.52 (0.95-2.45)
Cartilage injuries				
Chinese				
≥0-3 mo	16 (4.8)	72 (21.4)	—	1.00
>3-6 mo	16 (4.8)	88 (26.2)	.60	0.18 (0.38-1.75)
>6-12 mo	13 (3.9)	56 (16.7)	.92	1.05 (0.46-2.35)
>12 mo	25 (7.4)	50 (14.9)	.026	2.25 (1.09-4.64)
Age ≥30 y				
≥0-3 mo	15 (9.6)	23 (14.6)	—	1.00
>3-6 mo	11 (7.0)	29 (18.5)	.26	0.58 (0.22-1.51)
>6-12 mo	12 (7.6)	23 (14.6)	.65	0.80 (0.31-2.08)
>12 mo	17 (10.8)	27 (17.2)	.92	0.97 (0.40-2.35)

^aOR, odds ratio.

series in Singapore²⁴ in which 60.5% were Chinese, 23.0% were Malay, 8.46% were Indian, and 8.11% were of other origins.

A significant association between Chinese ethnicity and a higher prevalence of cartilage injuries was observed, which is a new finding that has not been reported before. Based on the Beijing Osteoarthritis Study,³² elderly women (≥60 years) in Beijing, compared with women of the same age in the Framingham Study, had a higher prevalence of both radiographic knee osteoarthritis (Chinese, 46.6% vs white, 34.8%; prevalence ratio, 1.45 [95% CI, 1.31-1.60]) and symptomatic knee osteoarthritis (Chinese, 15.4% vs white, 11.6%; prevalence ratio, 1.43 [95% CI, 1.16-1.75]). More specifically, Chinese elderly women had a greater prevalence of bilateral radiographic knee osteoarthritis (Chinese, 34.1% vs white, 19.7%; prevalence ratio, 1.92 [95% CI, 1.67-2.20]). This finding came as a surprise, given the lower BMI in Chinese patients. The authors attributed the discrepancy to a possible difference in the degree of physical activity in the Chinese compared with American whites. While we are unable to identify specific reasons for the association of Chinese ethnicity with cartilage injuries in ACL tears, genetic predisposition and differences in physical activity levels should be considered. Our observations suggest that Chinese ethnicity may be associated with cartilage injuries and subsequent degeneration. The reasons for the lack of correlation between Chinese ethnicity and concomitant meniscus injuries remain unclear.

Previous studies have proven significant associations between the presence of bone contusions on MRI and concomitant injuries sustained. For example, isolated lateral

femoral condyle and lateral tibial plateau bone contusions have been associated with lateral meniscus tears.^{5,26,31} This has led to the postulation that bone contusions indicate a greater severity of injury, are a reflection of higher energy injuries, and are thus potential markers for an increased risk of concomitant intra-articular injuries. In our study, we did not find a significant association between the presence of bone contusions and intra-articular injuries. This could be because of the lack of site-specific bone contusion analysis, which other studies have performed.^{5,26,31}

This study confirmed the association between increased age and concomitant cartilage injuries as reported by multiple authors^{6,7,10,14,19,27} and reaffirmed the relationship between aging and articular wear. This study also confirmed the association between male sex and meniscus tears (both medial and lateral), which is an association that has been extensively proven.^{7,10,12,14,19} It has long been attributed to the men probably having a higher energy mechanism of injury or increased activity levels in the interval period to surgical intervention. However, this has not been adequately studied thus far because of difficulties in quantifying the level of energy of the initial trauma and activity levels in the interim. The absence of statistically significant correlations between male sex and cartilage injuries in our data is supported by existing literature.^{7,12,14,19}

This study found no relevance of BMI on the presence of meniscus or cartilage injuries, consistent with Chen et al,⁹ who conducted a study in an Asian population. However, the majority of existing studies in Western populations by Brambilla et al,⁷ Kluzynski et al,¹⁴ and Barrett et al³ have proven its association. While it can be inferred that the higher mechanical load on the joints of overweight patients predisposes one to a more extensive knee injury, there is currently no explanation for the discrepancy between Asian and Western populations.

Studies by both Chen et al⁹ and Kluzynski et al¹⁴ had observed a correlation of cartilage injuries related to ACL tears sustained after the application of injurious forces through direct contact. However, in our study, we observed noncontact mechanisms giving rise to a trend towards a higher prevalence of cartilage injuries, with an odds ratio of 1.56 ($P = .11$) on multivariate analysis. This may be because of noncontact mechanisms resulting in higher energy trauma and a greater severity of injury. In a study by Viskontas et al,²⁹ a noncontact mechanism of injury was found to impart greater amounts of energy compared with a contact mechanism, and more severe bone bruising was seen in the noncontact group.

Among the high-risk patients identified in this study, male patients and Chinese patients had significantly fewer concomitant medial meniscus tears and cartilage injuries, respectively, when surgery was carried out within 12 months of the index trauma. Our findings are in agreement with Brambilla et al,⁷ who performed a detailed analysis on the timing of surgery by comparing the rate of injuries between 6 different intervals: 0-3, 3-6, 6-12, 12-24, 24-60, and >60 months. Their study showed a significant increase in medial meniscus tears and medial compartment

cartilage injuries beyond 12 months from the injury compared with patients who underwent surgery within 3 months of the injury.

In our study, time to surgery did not significantly alter the prevalence of lateral meniscus tears. This may be because lateral meniscus tears occur more commonly at the time of the primary injury rather than during secondary instability episodes after the initial injury.^{7,10} Previous studies have identified durations as short as 6 weeks from the injury to be of significance in reducing the prevalence of concomitant intra-articular injuries. However, findings have often been conflicting.^{9,10,14,19,21,27} Additionally, none of these studies analyzed high-risk patients specifically and thus would not be suitable for comparison.

An important strength of this study was that it involved a large and comparable sample size to published studies on factors associated with intra-articular injuries in ACL tears. This allowed an accurate analysis and evaluation of multiple variables. Our data were largely consistent with findings from the existing literature, especially on multivariate analysis, proving the reliability of our methodology and findings.

Our study had a number of limitations. First, data collection was retrospective in nature, and there was a lack of complete sets of data in our cohort. However, we reported data from a large number of patients ($N = 696$), and all components of our results were analyzed from at least 89% of our cohort. Second, our analysis on ethnicity was performed based on a dichotomy of Chinese and non-Chinese patients. Hence, this study was unable to provide conclusions on the other ethnic groups specifically. Third, our study did not include patients who were managed conservatively, with particular relevance to older patients. This may potentially alter the results. However, we chose to focus on a surgical population to identify high-risk subgroups that would be amenable to surgical management. Fourth, the documentation of cartilage injuries on diagnostic arthroscopic surgery was not standardized with a classification system, such as the International Cartilage Repair Society (ICRS) classification, potentially generating interobserver variability in the diagnosis. However, our team consists of fellowship-trained knee surgeons who have had many years of experience and would have been able to identify the presence or absence of cartilage injuries. The severity grading of cartilage injuries was not considered for analysis in our study. Lastly, we did not include other variables that could potentially be linked to intra-articular knee injuries, such as the number of instability episodes or physical activity levels, because of the lack of standardized documentation. However, our study offered an analysis of an adequate number of variables including Chinese ethnicity, which has not been studied before.

CONCLUSION

We have identified a new association between Chinese ethnicity and concomitant cartilage injuries in ACL-deficient patients. This may reflect an underlying ethnic predisposition to cartilage injuries. Increased age (≥ 30 years) was

associated with an increased prevalence of cartilage injuries, and male sex was associated with both medial and lateral meniscus tears. Definitive reconstruction surgery should be performed within 12 months of the index injury to minimize the risk of sustaining further intra-articular injuries, particularly medial meniscus tears and cartilage injuries.

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