

Knee Buckling: Prevalence, Risk Factors, and Associated Limitations in Function

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Background: Knee buckling is common in persons with advanced knee osteoarthritis and after orthopedic procedures. Its prevalence in the community is unknown.

Objective: To examine the prevalence of knee buckling in the community, its associated risk factors, and its relation to functional limitation.

Design: Cross-sectional, population-based study.

Setting: The Framingham Osteoarthritis Study.

Participants: 2351 men and women age 36 to 94 years (median, 63.5 years).

Measurements: Participants were asked whether they had experienced knee buckling or “giving way” and whether it led to falling. They were also asked about knee pain and limitations in function by using the Short Form-12 and Western Ontario and McMaster Universities Osteoarthritis Index, had isometric tests of quadriceps strength, and underwent weight-bearing radiography and magnetic resonance imaging of the knee. Radiographs were scored for osteoarthritis by using the Kellgren–Lawrence scale, and magnetic resonance images were read for anterior cruciate ligament tears. The relationship of buckling to functional limitation was examined

by using logistic regression that adjusted for age, sex, body mass index, and knee pain severity.

Results: Two hundred seventy-eight participants (11.8%) experienced at least 1 episode of knee buckling within the past 3 months; of these persons, 217 (78.1%) experienced more than 1 episode and 35 (12.6%) fell during an episode. Buckling was independently associated with the presence of knee pain and with quadriceps weakness. Over half of those with buckling had no osteoarthritis on radiography. Persons with knee buckling had worse physical function than those without buckling, even after adjustment for severity of knee pain and weakness. For example, 46.9% of participants with buckling and 21.7% of those without buckling reported limitations in their work (adjusted odds ratio, 2.0 [95% CI, 1.5 to 2.7]).

Limitation: Causal inferences are limited because of the study's cross-sectional design.

Conclusion: In adults, knee buckling is common and is associated with functional loss.

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Knee buckling is the sudden loss of postural support across the knee at a time of weight bearing. Affected persons often characterize this phenomenon as “giving way.” One study has suggested that the prevalence of knee buckling is high in selected persons seeking physical therapy and stability training for knee osteoarthritis (1). However, the prevalence of knee buckling in the community and its effect on physical function have not been described.

Buckling occurs mostly in persons with knee pain, and frequent knee pain affects about 25% of adults (2). Many of these persons have osteoarthritis of the knee (3). Whereas buckling and instability are a focus of orthopedic literature, these phenomena are neglected in medicine textbooks in chapters on knee pain or osteoarthritis (4, 5).

When buckling is discussed, it is identified as evidence of an internal derangement, such as an anterior cruciate ligament (ACL) tear (5). A search of MEDLINE for articles on knee instability (subject), buckling, or giving way (words in title or abstract) from 1966 through June 2007 revealed that articles on knee buckling or instability were found almost exclusively in the orthopedic literature, where it was noted as a complication of surgery (6, 7); a hallmark symptom of ACL tear (8); or a consequence of specific, uncommon conditions, such as patellar dislocation (9). Thus, buckling is not generally described in native, uninjured knees.

Buckling and symptoms of impending falling may be treatable or at least prevented, but avoiding activities that precipitate buckling may limit function. Buckling may cause falls and fractures and may help to explain the increased risk for hip fracture in patients with osteoarthritis who have higher bone density than others their age and who, therefore, should be at diminished risk for fracture (10).

We sought to characterize the frequency of knee buckling in the previous 3 months among persons from the community. We also evaluated whether buckling was associated with particular characteristics, such as knee or other joint pain or muscular weakness. Finally, we examined the relationship of buckling with physical function and deter-

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mined whether, independent of knee pain, buckling was associated with limited function.

METHODS

Participants

Our study cohort consisted of members of the Framingham Offspring Study and a newly recruited cohort from Framingham, Massachusetts. We combined these participants into a single cohort that we designated the “Framingham Osteoarthritis Study cohort.” Participants were examined between 2002 to 2005.

Participants in the Framingham Offspring Study included surviving descendants and spouses of descendants of participants in the original Framingham Heart Study. The Framingham Osteoarthritis Study is a population-based study of osteoarthritis. As part of a study of the inheritance of osteoarthritis, descendants of the original Framingham Heart Study cohort (the descendants of the original cohort and their spouses constitute the Framingham Offspring) whom we had studied for knee or hand osteoarthritis in earlier Framingham Osteoarthritis studies (11) were selected. This allowed us to examine inheritance patterns of osteoarthritis and genetic linkage. Selected Framingham Offspring were originally examined from 1992 to 1995 (11). All surviving members of this group and those not lost to follow-up were contacted by a letter of invitation, and those interested in participating received a follow-up telephone call to schedule clinic examinations (**Appendix Figure 1**, available at www.annals.org).

The newly recruited participants to the Framingham Osteoarthritis Study were drawn from a random sample of the Framingham, Massachusetts, community. Participants were recruited by using random-digit dialing and U.S. census tract data from 2000 to ensure inclusion of a representative sample of the community (**Appendix Figure 2**, available at www.annals.org). To increase participation of eligible persons in contacted households, a press release was sent to the local media and public officials and flyers were hung in public areas to heighten awareness of the study, which focused on musculoskeletal health. To be included, persons had to be at least 50 years of age and ambulatory. Bilateral total knee replacement and rheumatoid arthritis were the exclusion criteria. Rheumatoid arthritis was assessed by using a validated survey instrument (12) supplemented by questions about medication use that would reflect treated disease. Participant selection was not based on the presence or absence of knee osteoarthritis or knee pain.

The study was approved by the Boston University Medical Center institutional review board. All participants provided written informed consent.

Assessment of Buckling

We informed all participants that “we are interested in knee buckling, which is also called ‘giving way.’” We asked, “Have you had an episode in the past 3 months where your knee buckled or gave way?” Persons who an-

Context

Knee buckling is the sudden loss of postural support across the knee at a time of weight bearing. Its prevalence and consequences are not clear.

Contribution

This study of 2351 community-dwelling, middle-age and older adults found that 278 participants (12%) reported at least 1 episode of knee buckling in the past 3 months. Of these, 13% fell during the episode. Knee pain, quadriceps weakness, and worse physical function were associated with buckling.

Caution

The study's cross-sectional design limits causal inferences.

Implications

Knee buckling occurs commonly among middle-age and older adults and is sometimes associated with functional limitations.

—The Editors

swered “yes” were asked to indicate which knee gave way, how many times in the past 3 months they had had such an episode, and whether knee buckling precipitated a fall. We also asked what they were doing when their knee buckled and offered 4 options (they could choose more than 1): walking, going up or down stairs, twisting or turning, or other. We chose a 3-month period because other studies have suggested that recollection of falling was accurate for approximately 3 months after the event (13).

We considered a person who answered “yes” to the initial question on buckling as having experienced buckling. We also examined the subgroup of participants who had had more than 1 episode of buckling in the past 3 months.

Pain, Physical Limitation, and Assessment of Risk Factors

We asked participants about knee symptoms by using the following question: “In the past 30 days, have you had any pain, aching, or stiffness in either of your knees?” We considered all persons who said “yes” to have knee pain. A positive response triggered the follow-up question, “Is the pain, aching, or stiffness in your right knee, left knee, or both knees?” We assessed knee pain in the past week by using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) questionnaire, a validated instrument for assessment of knee pain and disability (14).

To evaluate the effect of buckling on physical function or limitation, we used WOMAC and the Short Form (SF-12) as self-reported measures of physical function or limitation. The WOMAC has a physical function subscale consisting of 17 questions, each of which asks about a different type of activity and whether knee problems limit

the respondent in performing those activities. Each item is scored on a scale of 0 to 4 on the basis of the amount of limitation experienced; the total score ranges from 0 to 68, with 68 constituting profound limitation and 0 constituting none. In addition, we used items from the SF-12 (15, 16) to gather information on specific physical functional limitations that might be affected by buckling. The items we focused on from the SF-12 were whether participants were limited in moderate activities, in climbing several flights of stairs, and in the type of work or other activities they could do and whether they accomplished less than they wanted.

Isometric quadriceps strength was measured while participants were sitting in a straight-backed chair by using a strain gauge dynamometer strapped to the lower leg. The force exerted when the knee was extended was recorded. Three measurements were made on each leg, and the maximum of the 3 was chosen as the measure of leg strength. For a person, we used the maximal leg strength.

More than 90% of participants had all assessments completed during 1 clinic visit. Occasionally, participants were scheduled to return within 2 weeks for magnetic resonance imaging (MRI).

Radiographic Assessments

All participants underwent bilateral weight-bearing radiography using a posteroanterior fixed-flexion approach with a SynaFlex frame (Synarc, San Francisco, California), and a lateral weight-bearing semiflexed film was obtained according to a recently published protocol (17). Radiographs were scored on the Kellgren–Lawrence scale (18); a knee was considered to have radiographic osteoarthritis if its grade was 2 or greater. Patellofemoral osteoarthritis was characterized on the lateral view by using a validated approach (19). A bone and joint radiologist and an experienced rheumatologist each read roughly one half of the films. The intrareader κ value for Kellgren–Lawrence grade was 0.82, and the interreader κ value was 0.74 ($P < 0.001$ in both cases).

MRI Assessment of ACL Integrity

Magnetic resonance imaging was not done or read for all knees of all participants (Appendix Figures 1 and 2, available at www.annals.org). Because of monetary constraints, only the right knees of community-based participants were read for ACL tears and other features. Neither acquisition nor reading of MRIs depended on the reporting of buckling.

All studies were performed with a 1.5-T MRI system (Siemens, Mountain View, California) using a phased-array knee coil. A positioning device was used to ensure uniform placement of the knee among participants. T2-weighted, fat-suppressed images in the sagittal and coronal planes were acquired, using the following pulse sequence: repetition time, 3610 msec; echo time, 40 msec; slice thickness, 3.5 mm; and field of view, 14 cm. T1-weighted spin echocardiography images in the sagittal plane were

acquired, using the following pulse sequence: repetition time, 480 msec; echo time, 24 msec; slice thickness, 3.5 mm; and field of view, 14 cm. A 3-dimensional fast flow angle shot water-excitation sequence (resolution, $0.3 \times 0.3 \times 1.5$ mm) was acquired in the coronal and axial planes; the pulse sequence was repetition time, 18.4 msec; echocardiography time, 9.3 msec; slice thickness, 1.5 mm; and field of view, 16.4 cm.

The ACL was evaluated on the sagittal and coronal views and was scored as torn or not torn by 1 of 2 readers, both of whom were bone and joint radiologists. Agreement between the readers for presence of an ACL tear was a κ value of 1.0 ($P < 0.001$).

Statistical Analysis

To evaluate the association of buckling with risk factors, we performed knee-specific logistic regression in which the dependent variable was buckling and the independent variables were age, sex, body mass index (BMI), and quadriceps strength. Analyses used generalized estimating equations to adjust for the correlation of 2 knees within a person.

To examine limitation in activities and its relationship to buckling, we used a person-specific polychotomous logistic regression model in which the outcome was limitation in activity and “no limitation” was the reference category. “Limited a little” and “limited a lot” were the 2 levels of outcome. The independent variable for this model included presence or absence of buckling in either knee, and we sequentially adjusted for WOMAC pain score (a critical correlate of disability) and then age, BMI, sex, and quadriceps strength.

To evaluate the association of buckling with WOMAC disability scores (a person-specific measure), we performed a linear regression analysis in which the dependent variable was the continuous WOMAC disability score and independent variables were the presence or absence of buckling and the WOMAC pain score. Next, we added age, BMI, and quadriceps strength to this regression analysis as independent variables. For all analyses, we tested for interactions of primary variables with sex and BMI. Among these, we found that the relation of buckling to WOMAC physical function score differed by sex (at $P < 0.05$), and we therefore performed sex-specific analyses.

Role of the Funding Source

The study was supported by the National Institutes of Health. The funding source had no role in the design, conduct, or analysis of the study.

RESULTS

The 2351 participants ranged in age from 36 to 94 years (median, 63.5 years). Two hundred seventy-eight participants (11.8%) experienced at least 1 episode of buckling of either knee in the past 3 months; of these participants, 217 (78.1%) had more than 1 episode of knee

buckling and 35 (12.6%) fell during an episode. Of persons with knee buckling, 136 reported walking, 97 reported stair climbing, and 71 reported twisting or turning at the time of buckling; some reported more than 1 such activity. No specific other activity was common during buckling.

When we examined the demographic and disease-related attributes of persons who experienced knee buckling, we found that buckling was equally common in both sexes and did not increase in prevalence with age (Table 1). However, buckling increased in prevalence with greater BMI, occurring in only 7.7% of persons in the lowest quartile of BMI but in 17.6% of those in the highest quartile (Table 1). The prevalence of knee pain and buckling was similar in the community cohort and in the Framingham Offspring Study cohort.

Buckling was far more common in knees with pain at any time in the past 30 days (14.1% of knees with pain experienced buckling) than in knees with no pain at all (2.1%). The prevalence of buckling was 26.7% among knees with pain rated as severe compared with 9.9% among knees with pain rated as mild.

Buckling was more common in knees with radiographic osteoarthritis in the tibiofemoral joint than in those without this condition (11.0% vs. 4.7%). Among knees with radiographic osteoarthritis, buckling occurred most often in knees with both tibiofemoral and patellofemoral disease. Even so, most persons with buckling had pain in the affected knee but did not have osteoarthritis in that knee on radiography.

The prevalence of buckling increased with the number of nonknee joints in either leg that were painful. For example, participants who reported hip pain in addition to knee pain also reported buckling more often than those who reported only knee pain. Finally, quadriceps strength was related to buckling, which occurred in 8.7% of knees in the lowest quartile of quadriceps strength compared with 3.0% of those in the highest quartile (Table 1). Among right-knee MRIs that were read, 101 knees had buckling; of these, only 12 (11.9%) had ACL tears. Of MRIs of knees without buckling, 42 of 1159 (3.6%) had ACL tears (3.6%).

When we examined risk factors associated with buckling, we found that buckling was inversely related to quadriceps strength and that quadriceps strength was associated with buckling risk independent of age, sex, and BMI (Table 2).

Buckling was also associated with the overall level of physical function. Fifty percent of participants reporting any episodes of buckling and more than half of participants who had more than 1 episode were either limited a little or limited a lot in their overall activities (Table 3). Participants with buckling had a significantly increased risk for being limited a little or limited a lot (odds ratio for "limited a lot," 1.9 [95% CI, 1.6 to 2.4]) (Table 3). Even after adjustment for the degree of pain in the knee and for age,

Table 1. Participant Characteristics and Prevalence of Knee Buckling

Characteristic	Participants, n/n (%)
Knee pain*	
Any knee pain	223/1587 (14.1)
No knee pain	61/2949 (2.1)
Age	
36–57 y	68/599 (11.4)
58–63 y	70/563 (12.4)
64–71 y	71/618 (11.5)
72–94 y	69/571 (12.1)
Sex	
Male	113/1022 (11.1)
Female	165/1329 (12.4)
Body mass index	
<24.8 kg/m ²	45/584 (7.7)
24.8 to <27.8 kg/m ²	55/584 (9.4)
27.8 to <31.3 kg/m ²	71/585 (12.1)
≥31.3 kg/m ²	103/584 (17.6)
Knee injury*	
History of knee injury	78/498 (15.7)
No history of knee injury	205/4028 (5.1)
Number of other leg joints with pain	
0	148/3472 (4.3)
1	67/688 (9.7)
2	41/215 (19.1)
≥3	28/177 (15.8)
Adjusted quadriceps strength†	
Quartile 1 (weakest)	86/986 (8.7)
Quartile 2	62/980 (6.3)
Quartile 3	31/993 (3.1)
Quartile 4 (strongest)	30/991 (3.0)
Osteoarthritis status*‡	
No osteoarthritis	173/3636 (4.8)
Isolated tibiofemoral osteoarthritis	55/541 (10.2)
Isolated patellofemoral osteoarthritis	5/70 (7.1)
Combined tibiofemoral and patellofemoral osteoarthritis	43/243 (17.7)
Kellgren–Lawrence grade of tibiofemoral osteoarthritis*	
0	160/3453 (4.6)
1	19/263 (7.2)
2	41/387 (10.6)
≥3	58/400 (14.5)
Patellofemoral osteoarthritis*‡	
Absent	229/4187 (5.5)
Present	48/313 (15.3)

* Data are presented by knee, not by person. Some participants had buckling in 1 knee with pain and in 1 knee without pain; the numbers therefore exceed 278 persons with knee buckling.

† Quadriceps strength divided by body weight.

‡ As determined by radiography.

sex, and BMI, knee buckling remained independently associated with physical limitation.

Of participants with knee buckling, roughly two thirds noted a little or a lot of limitation on climbing stairs, and even after adjustment for pain, buckling was associated

Table 2. Association of Risk Factors with Knee Buckling

Risk Factor	Odds Ratio for Knee Buckling (95% CI)	
	Crude	Adjusted
Quadriceps strength/ body weight (per n/kg)*	0.017 (0.004–0.065)	0.027 (0.006–0.122)
Age (per year)	–	1.01 (0.99–1.03)
Male sex	–	1.13 (0.80–1.60)
Body mass index (per kg/m ²)	–	1.04 (1.01–1.07)

* Interactions of sex and body mass index with quadriceps strength were not statistically significant at $P < 0.05$.

with limitations in climbing stairs (Table 3). Roughly half of participants with buckling accomplished less than they would like and were limited in the kind of work that they could do. The odds for work limitation among participants with buckling was increased more than 3-fold compared with those without buckling, an increased risk that persisted after adjustment.

Persons with knee buckling had higher mean WOMAC disability scores than did those without buckling (Table 4). The higher score for disability among persons with knee buckling was independent of pain severity, weakness, age, and BMI.

DISCUSSION

In a community-based study, we found that knee buckling is common, occurring in more than 10% of persons. Buckling occurred most often in persons with knee pain and was related to limitations in physical function,

especially stair climbing. Given the aging of the population, knee buckling will probably become more frequent.

Knee buckling is not included in the list of common symptoms in persons with knee problems or knee osteoarthritis in medical or rheumatology textbooks. We found that buckling not only is common but is also associated with limitations in physical function and that persons with buckling have a high rate of falling.

Why does buckling occur so often? Buckling is the sudden loss of postural support across the knee during weight bearing. It usually occurs when weight-bearing demands are increased, such as when going up or down stairs. This sudden “giving way” can occur because of pain, knee instability, or insufficient muscle strength to support body weight at a time of increased demand. Many patients who have experienced repeated buckling and anticipate particular activities that induce it avoid those activities or use another means of support, such as holding onto banisters when coming down stairs, to avoid the most serious consequences of buckling—an injurious fall.

Despite its prevalence and impact, a MEDLINE search for articles on buckling, knee instability, or giving way suggests that literature is scarce on buckling in non-orthopedic settings. In a study of persons referred to physical therapy for stability training with knee osteoarthritis, Fitzgerald and colleagues (1) reported similar findings to ours—a relation of buckling to physical functional limitation, independent of pain, and a relation of buckling with quadriceps weakness. Case studies of individuals with buckling have suggested that during gait cycles that produce buckling, knee flexion angle is greater than that during gait cycles without buckling in the same knee (8). Other investigations of instability have focused on persons

Table 3. Knee Buckling and Limitation of Physical Function and Physical Role on the Short Form-12

Criterion	Participants with Disability, n (%)		Odds Ratio for Knee Buckling (95% CI)		
	Without Knee Buckling	With Knee Buckling	Crude	Adjusted 1*	Adjusted 2†
Limited in moderate activities					
Limited a lot	118 (5.8)	39 (14.1)	1.9 (1.6–2.4)	1.4 (1.2–1.8)	1.4 (1.1–1.8)
Limited a little	385 (18.8)	99 (35.9)	1.7 (1.5–2.0)	1.3 (1.2–1.6)	1.3 (1.1–1.6)
No limit	1546 (75.4)	138 (50.0)	1.0 (referent)	1.0 (referent)	1.0 (referent)
Limited in climbing several flights of stairs					
Limited a lot	142 (6.9)	60 (21.3)	2.4 (2.0–2.9)	1.8 (1.4–2.2)	1.7 (1.3–2.3)
Limited a little	530 (25.9)	116 (42.3)	1.8 (1.5–2.0)	1.4 (1.2–1.6)	1.5 (1.2–1.8)
No limit	1373 (67.1)	98 (35.8)	1.0 (referent)	1.0 (referent)	1.0 (referent)
Accomplished less					
Yes	462 (22.7)	131 (48.3)	3.2 (2.5–4.1)	2.0 (1.5–2.7)	2.0 (1.5–2.8)
No	1577 (77.3)	140 (51.7)	1.0 (referent)	1.0 (referent)	1.0 (referent)
Limited in kind of work					
Yes	439 (21.7)	127 (46.9)	3.2 (2.4–4.1)	2.0 (1.5–2.6)	2.0 (1.5–2.7)
No	1583 (78.3)	144 (53.1)	1.0 (referent)	1.0 (referent)	1.0 (referent)

* Adjusted for Western Ontario and McMaster Universities Osteoarthritis Index pain score.

† Adjusted for Western Ontario and McMaster Universities Osteoarthritis Index pain score, age, body mass index, sex, and quadriceps strength.

Table 4. Buckling and Physical Functional Limitation, by Western Ontario and McMaster Universities Osteoarthritis Index Score*

Participants	WOMAC Physical Function Score (95% CI)†		
	Crude	Adjusted 1‡	Adjusted 2§
Men			
With buckling	15.0 (13.3–16.6)	8.2 (7.3–9.2)	8.1 (7.1–9.0)
Without buckling	4.9 (4.3–5.4)	5.7 (5.4–6.0)	5.6 (5.3–5.9)
Women			
With buckling	15.7 (14.3–17.2)	9.2 (8.3–10.1)	9.1 (8.2–10.0)
Without buckling	6.6 (6.0–7.1)	7.5 (7.2–7.8)	7.5 (7.2–7.8)

* Results are presented by sex because testing for interaction showed that there were sex differences in the relation of buckling with WOMAC physical function score. WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index.

† Possible range of 0 (no disability) to 68 (profound limitation).

‡ Adjusted for WOMAC pain score.

§ Adjusted for WOMAC pain score, age, body mass index, sex, and quadriceps strength.

|| $P < 0.001$ compared with score for participants without buckling.

with ACL tears or knee dislocation or those who have recently had knee surgery, and each has characterized different anatomical or physiologic factors that might predispose to instability symptoms (6, 7, 20). These have not been investigated in the general community in nonoperated or nondislocated knees.

Persons with knee osteoarthritis are at increased risk for fracture (21). This risk is paradoxical, given the high BMI (22) and high bone mineral density of persons with knee osteoarthritis (23). We suggest that knee buckling and consequent falling account for this increased fracture risk. Our data point to a clinical problem that might be addressable and therefore may improve physical function and lessen fear among persons with knee problems. We suggest that asking patients with knee problems whether they have buckling might identify and prevent consequential events that follow from buckling and falling.

Instability of the knee is thought to be highly treatable (1). Indeed, our data highlight an association with one risk factor, quadriceps weakness. Because our data are cross-sectional, we cannot make causal inferences regarding the relation of quadriceps weakness with buckling, but quadriceps strengthening and balance training are elements of successful rehabilitative efforts to treat instability (24).

Limitations of our study include the absence of comprehensive anatomical and dynamic biomechanical information that might provide a more pathophysiologic understanding of buckling, including gait, neurosensory, and knee instability data. Such intensively detailed data are beyond the capability of large-scale survey studies, but future studies should focus on preventable causes of buckling. In addition, we can only speculate as to whether buckling underlies the increased risk for fractures in patients with knee osteoarthritis, because too few of our participants had fractures to study this issue. Causal inferences are limited

because of the study's cross-sectional design. We did not include physical examinations for ligamentous abnormalities, although the reproducibility of these examinations is limited. Ultimately, we used MRIs to identify ACL tears, the ligamentous finding thought to be most strongly associated with buckling. We do not have information on loose bodies, which have been linked uncommonly with buckling in persons with osteoarthritis. Finally, recall of knee buckling may have been imperfect.

In conclusion, knee buckling is common, especially in persons with knee problems. Buckling is associated with functional limitation independent of knee pain.

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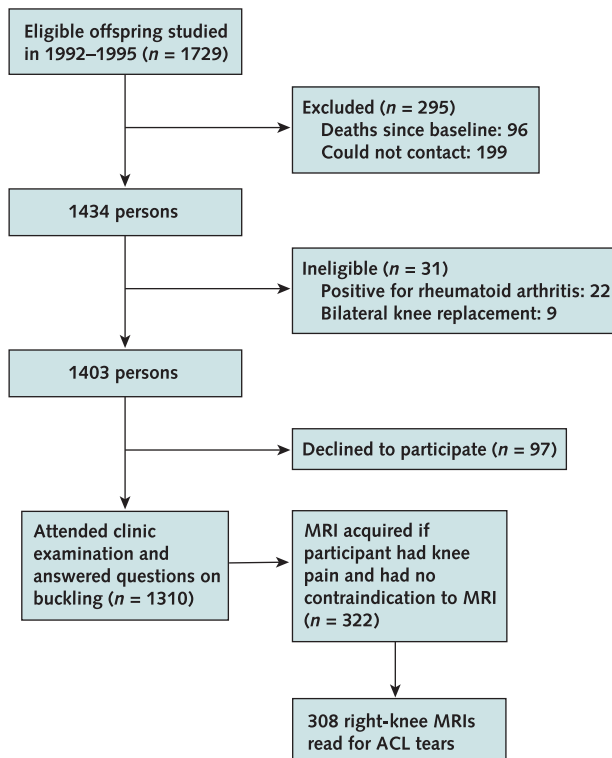
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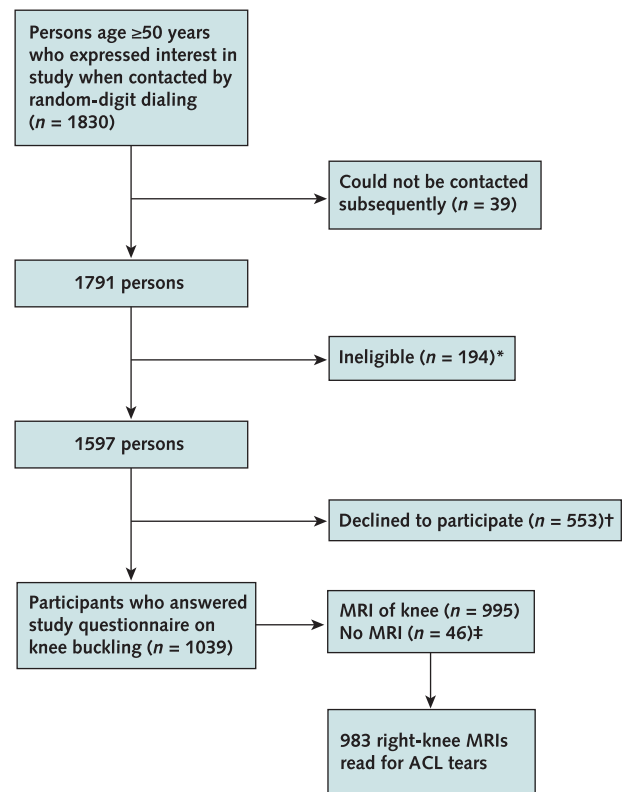
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Appendix Figure 1. Study flow diagram: the Framingham Offspring Study cohort.



Appendix Figure 2. Study flow diagram: the Framingham Osteoarthritis Study community cohort.



ACL = anterior cruciate ligament. *Members of Framingham Offspring Study, positive screening for rheumatoid arthritis, magnetic resonance imaging (MRI) contraindicated, bilateral knee replacement, dementia or terminal cancer, or planned to move from area. †Declined to participate because of cancer, chronic illness, no interest when received full details of the study, no reason given, no time, declined MRI or radiography, or other reasons. ‡Not done because of claustrophobia, medical contraindications, or problems with scheduling.

ACL = anterior cruciate ligament; MRI = magnetic resonance imaging.