Differences in injury pattern and prevalence of cartilage lesions in knee and ankle joints: a retrospective cohort study

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Abstract

Osteoarthritis (OA) is more common in the knee compared to the ankle joint. This can not be explained exclusively by anatomical and biomechanical differences. The aim of this study is to analyze and compare the injury pattern (clinically) and the cartilage lesions (arthroscopically) of knee and ankle joints in a cohort of patients from the same catchment area. A retrospective study of the clinical data of 3122 patients (2139 outpatients and 983 inpatients) was performed, who were treated due to an injury of the knee and ankle joint. Statistical analysis was performed using SigmaStat 3.0 (SPSS Inc, Chicago, USA). There is a higher prevalence of injuries in the ankle as compared to the knee joint in this population from the same catchment area. In contrast, high-grade cartilage lesions are more prevalent in the knee, whereas low grade cartilage lesions are equally distributed between knee and ankle. From this data it can be concluded that the frequency of injuries and the injury pattern of knee *versus* ankle joints do not correlate with the severity of cartilage lesions and may therefore have no direct influence on the differential incidence of OA in those two joints.

Introduction

The incidence of osteoarthritis (OA) in the ankle is substantially smaller than in the knee. The so-called Framingham study showed a prevalence of approximately 6% of the adult population for knee OA, and that the percentage rises to over 10% among those over 65 years of age.[1] However, the incidence of symptomatic primary OA in the ankle is relatively rare (less than 1% of the population), and also does not increase with age.[2]

Nevertheless, the different incidence and prevalence of OA of both joints cannot be explained[3] exclusively with differences in anatomy and biomechanics. Unlike the ankle, the knee joint has menisci which function as fibrocartilaginous damper, and, compensate the mismatch between the tibial plateau and the femoral condyles. On the other hand they increase the articulating joint surfaces, thus reducing the load on the entire joint surface. Another difference between the knee and ankle joint is the variation of cartilage thickness. In the normal ankle, the average cartilage thickness of the talus is 1 to 1.7 mm. Cartilage thickness in the knee joint ranges from 1 to 6 mm, depending on the location.[4,5] The stiffness of normal ankle cartilage also shows little topographic variation within the principal loading zone, whereas the knee joint is much more heterogeneous.[6] An incomplete congruence with incomplete and separate contact surfaces can be found at low load in the ankle, with transformation into complete congruence at high load.[6] The loaded ankle joint has a smaller contact area than the loaded knee joint. At 500 N axial load, the contact area in the ankle is 350 mm^2,[7,8] compared to 1120 mm^2 in the knee joint.[9] It is herewith shown that due to the smaller contact areas and the lack of damping, the total load and the load peaks in the ankle are even higher than in the knee. The anatomical features as well as the biomechanical differences can not explain the increased frequency of osteoarthritis of the knee joint. Among the various factors that lead to the onset and progression of OA, traumatic injuries of joint structures, as they occur in intra-articular fractures, play an essential role. A biomechanical model shows that a traumatic injury to the articular surface results in an immediate loss of biomechanical function. Associated biochemical damage such as the loss of functionally important matrix components occur only in the post-traumatic course and may potentiate the risk of OA.[10] Twisting injuries of knee and ankle joints are among the most common injuries in sports. This can lead to ligament injuries, meniscus tears (in the knee), and cartilage and bone lesions with varying degrees of severity.

The aim of the study is to analyze and to compare the clinical pattern of injury and the cartilage damage in both joints in a cohort of patients of the same catchment area.

A retrospective analysis was performed using clinical data of patients who were treated conservatively as outpatients or arthroscopically as inpatients due to an injury of the knee and ankle joint between January 2001 and December 2005. The number and type of injuries and surgeries, as well as the frequency and distribution of cartilage damage in the knee and ankle joint were analyzed.

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Materials and Methods

Outpatients

Data of patients were analyzed who were treated between January 2001 and December 2005 in the emergency room of a hospital with a large local and regional catchment area due to an injury of the knee and ankle. Inclusion criteria were fresh injuries such as sprains and fractures of the knee and ankle. Exclusion criteria were old joint injuries, as well as clinically and/or radiologically verified OA.

Inpatients

The medical records of patients were analyzed, in which an arthroscopy of the knee or ankle joint was performed between January 2001 and December 2005 in the same hospital. Structural damage of the cartilage was documented intraoperatively in each operation report. The analysis was performed according to the evaluation scheme of the International Cartilage Repair Society (ICRS).[11] This classification consists of four degrees of damage (grade 1-4) plus normal cartilage (grade 0) (Table 1). Critical to note is the high inter-observer variability of this visual scale.[12] However, this was reduced by combining two degrees of damage per group (ICRS grade 1 and 2 for low grade cartilage damage, ICRS grade 3 and 4 for high grade cartilage damage). The investigations and treatments were performed at a hospital with a large rural catchment area, so the patient population is not pre-selected and potential bias is reduced.

Table 1. Cartilage damage grading system of the International Cartilage Repair Society (ICRS) [adapted from Brittberg *et al.*, 2000].

Grade 0	Normal	Intact cartilage with a smooth white surface and solid consistency
Grade 1	Slightly damaged	Softening of the surface possibly fibrillation of the superficial layer
Grade 2	Moderately damaged	Surface frayed down to the transition zone but less than 50% of total thickness
Grade 3	Severely damaged	Cartilage defect over 50% of the cartilage thickness subchondral bone intact
Grade 4	Very severely damaged	Cartilage defect over 50% of the cartilage thickness with injury of the subchondral bone

Statistical analysis

Data processing was based on the documented diagnosis key (according to ICD-10 coding) in the MCS ISYNET (version 6.56.1404 NFAArzt) for outpatients, or on the ICPM search list with the ORBIS Software (QRP version 1.01.02.002) and the digital patient file Pegasos for inpatients.

Statistical analysis was performed with SigmaPlot 8.0 and SigmaStat 3.0 (SPSS Inc, Chicago, USA). Firstly, a test for normal distribution was performed for each record. Depending on whether it was a normally distributed or not normally distributed sample, the specific test was performed, including analysis of variance (ANOVA). The significance level was set at $P \leq 0.05$.

Results

A retrospective analysis of the medical records from a total of 3122 patients with injuries of the knee and ankle joint was performed (Table 2). The age distribution shows no significant differences, whereas the gender ratio showed a slight predominance of injury in men.

Outpatients

Age and gender distribution of out-patients are shown in Table 2. Statistically significant differences between knee and ankle are not present. However, men show more knee and ankle injuries compared to women.

Outpatients show twice the number of injuries to the ankle (1409 injuries) compared to the knee joint (730 injuries). Data analysis is shown in Table 3. Of particular interest is that articular fractures in the ankle occur 2.8 times more often than in the knee joint. For capsular and ligament lesions, the ratio of knee to ankle is even 1 to 4.2. This suggests that the stability-affecting capsular and ligament lesions occur about 4 times as much in the ankle compared with the knee joint. In contrast, joint contusions, who do not affect joint stability, are more common in the knee than the ankle (ratio about 2 to 1). In 18 cases, knee joint effusion or hemarthrosis of the knee were detected. Capsular and ligament lesions of the knee occur in 34.11 % of cases compared to 75.59% in the ankle. Fractures in the knee (6.3% of cases) are also less frequent than in the ankle (9.23%). Knee contusion, however, occurred significantly more frequent in the knee than in the ankle (59.59 % *versus* 15.18%).

Table 2. Age and gender distribution of patients treated as outpatients and inpatients between January 2001 and December 2005 due to an injury to the knee and ankle. Shown are age, mean ± standard deviation (SD), the median with minimum and maximum value (min-max), and the gender distribution (♂ / ♀) absolutely (n) and in %.

	Outpatients (n=2139)	Inpatients (n=983)
Age		
Mean±SD	41.8±22.5	39.6±17.1
Median (min-max)	43.2 (2.9-89.3)	40.8 (3.1-80.1)
Gender (♂/♀)		
N.	1196/943	509/474
%	55.9/44.1	51.8/48.2
Outpatients	**Knee (n=730)**	**Ankle (n=1409)**
Age		
Mean±SD	43.4±19.3	41.6±20.2
Median (min-max)	41.9 (2.9-89.3)	40.8 (5.5-83.6)
Gender (♂/♀)		
N.	392/338	734/675
%	53.6/46.3	52.1/47.9
Inpatients	**Knee (n=755)**	**Ankle (n=228)**
Age		
Mean ± SD	40.1±18.8	39.1±15.3
Median (min-max)	41.3 (3.1-80.1)	40.3 (9.3-75.3)
Gender (♂/♀)		
N.	388/367	120/108
%	51.4/48.6	52.6/47.4

Table 3. Main diagnoses of injuries to knee and ankle joints in patients who were treated between January 2001 and December 2005 in the emergency center of the hospital.

	Knee		Ankle	
	N.	%	N.	%
Capsule and ligament-lesion	249	34.1	1065	75.6
Contusion	435	59.6	214	15.2
Fracture	46	6.30	130	9.23
Total	730	100	1409	100

Inpatients

Between January 2001 and December 2005, 755 knee arthroscopies and 228 ankle arthroscopies were performed. The age and gender distribution is shown in Table 2. Statistically significant differences do not exist. Cartilage lesions were graded according to the ICRS classification and documented in the operation report.[11] The distribution is shown in Figure 1. There is a higher prevalence of high-grade cartilage lesions (ICRS grade 3 and 4) in the knee (49.47%) compared to the ankle (26.31%), whereas non-damaged cartilage (grade 0) occurs in 42.1% of the ankle, but was found in only 15.96% of the knee joints. The relative number of low-grade cartilage lesions (ICRS grade 1 and 2) in the knee (34.97%) is similar to the ankle (31.58%). Within this group, the ankle shows significantly more

grade 1 lesions and less grade 2 lesions compared to the knee.

Of particular interest is that low-grade cartilage lesions occur in the knee and ankle with almost equal frequency (ratio 1.1 to 1), but high-grade cartilage defects are significantly more prevalent in the knee (ratio 1.9 to 1). Moreover, the rate of low-grade to high-grade lesions in the knee joint increased from 34.97% to 49.47%, whereas it remains approximately the same in the ankle or even tends to be lower (from 31.58% to 26.31%). In contrast, injuries which are suitable to cause severe intra-articular damage (such as sprains and fractures) occur more frequently in the ankle than in the knee joint. This suggests that there might exist specific mechanisms in the ankle, which prevent the progression of low-grade cartilage damage.

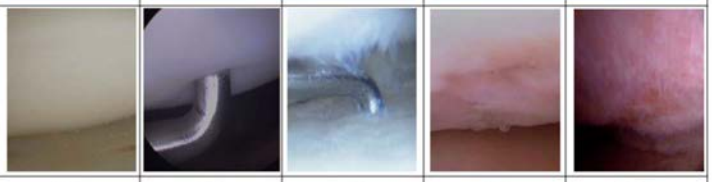
	Grade 0	Grade 1	Grade 2	Grade 3	Grade 4
	normal	low grade		high grade	
					
Knee [n]	120	84	179	124	248
%	*15,96*	*11,17*	*23,80*	*16,49*	*32,98*
Ankle [n]	96	52	20	20	40
%	*42,10*	*22,81*	*8,77*	*8,77*	*17,54*
Knee [%]	15,96 %	34,97 %		49,47 %	
Ankle [%]	42,10 %	31,58 %		26,31 %	

Figure 1. Distribution of cartilage defects of the knee and ankle at arthroscopy according to the classification of the International Cartilage Repair Society (ICRS). The images in the top half of the table show arthroscopic photographs of typical cartilage defects of the knee joint. In the bottom half of the table, the percentages of normal, low-grade and high-grade cartilage damage is shown.

Discussion

The statement of Hunter (1743), that *[...] ulcerated cartilage is a troublesome thing, and that once destroyed is not repaired* still has its actuality.[13] In fact, there is still no scientifically documented report on the repair or regeneration of a cartilage defect with hyaline cartilage in situ. Numerous studies, however, show the progression of traumatic cartilage damage and its importance in the development of OA.[14] The concepts for the etiopathogenesis of OA include two interrelated theories.[15] On the one hand side, OA is considered to be an age-related disorder of evolution. On the other hand, both metabolic and biomechanical disorders may lead to the development of OA. Joint injuries, such as fractures and sprains, hereby play an important role.

This retrospective analysis shows a significantly higher prevalence of fractures and sprains of the ankle compared to the knee. However, epidemiological, radiological and pathoanatomical studies indicate that the incidence of OA in the ankle is much lower than in the knee joint.[1,2] This suggests that specific mechanisms might exist in the ankle, which may counteract the development of post-traumatic OA. Despite the higher frequency of ankle injuries (as compared to the knee), arthroscopies performed during the same period for the knee is significantly higher than for the ankle. The different treatment strategies of sprains and ligament lesions in knee *versus* ankle joints could be responsible for this difference. Most ankle sprains, including those with ligament lesions, are being treated non-operatively. Twisting injuries to the knee may lead to meniscal tears and lesions of the cruciate and collateral ligaments, which often require surgical intervention. However, intraarticular fractures and osteochondral lesions are treated surgically in both the knee and the ankle.

Arthroscopic inspection of the knee showed damaged cartilage surfaces (ICRS grade 1-4) in 84%. Full-thickness cartilage defects (ICRS grade 4) are seen in 33% of the cases. This is in the range which was described by Curl *et al.*,[16] who analysed 31,516 knee arthroscopies. In the ankle, we found a total of 58% of cartilage damage (ICRS grade 1-4), but only 18% were full-thickness defects (ICRS grade 4). This also corresponds to the data of other authors. Studies performed by Hintermann *et al*.[17] of symptomatic, chronic unstable ankles showed cartilage damage in 54% of the talar and 23 % of the tibial surface. In the present study, high-grade cartilage lesions are significantly more prevalent in the knee compared to the ankle. This is also reported by others, but mainly patho-anatomic studies.[18-21] Due to the same age distribution in both groups, the increased rate of cartilage lesions in the knee can not be explained by an increased age at surgery. Meachim *et al*.[18,19] found cartilage defects down to the subchondral bone plate in 44% of knee joints, but only in 2% of the ankle. Muehleman *et al*.[20] found in knee and ankle joints of the same limb that 95% of the knee joints and 76% of ankles had degenerative changes. However, full-thickness defects reaching down to the subchondral bone plate were found in 66% of knees, but only in 18% of ankles. Sudies by Cole *et al*.[21] at approximately 4000 knee and ankle joints show an increased prevalence of high-grade cartilage defects in the knee, whereas non-damaged articular cartilage was predominantly found in the ankle. Low-grade cartilage damage was evenly distributed in knee and ankle. The results of this patho-anatomic study correspond to the results of our present study, which are based on arthroscopic findings after a joint injury. Herewith, it could be demonstrated that the prevalence of cartilage lesions is also reproducible in a larger group (about 4000 donors) and independent of a traumatic event.

Injuries which are likely to cause cartilage damage (sprains and fractures of the joint) occur more frequently in the ankle compared to the knee. However, the number of patients who were treated surgically is significantly higher in the knee. Intraoperative inspection of the articular surface shows an increased prevalence of high-grade cartilage lesions (ICRS grade 3 and 4) of the knee.

Interestingly, low-grade cartilage lesions (ICRS grade 1 and 2) occur with the same prevalence in both joints. Thus, the hypothesis of this study, *i.e.* that the different incidence of cartilage damage and OA of the knee and ankle is due to differences in injury rate or a different injury pattern, are not confirmed by the data presented here. The higher rate of injuries of the ankle (as compared to the knee), but the lower rate of surgery, and especially the mostly low-grade cartilage damage in the ankle suggests that there might be specific protective mechanisms in the ankle, which are not or only insufficiently developed in the knee joint. Some metabolic and structural differences between knee and ankle cartilage and chondrocytes have already been shown.[22,23] However, further clinical and experimental investigations are necessary.

Conclusions

The presented data regarding the prevalence and pattern of injuries of knee and ankle joints do not correlate with the higher rate of OA of the knee joint. In this cohort of patients, injuries in the ankle are more common than in the knee. However, high-grade cartilage lesions are more common in the knee, whereas low-grade cartilage damage is evenly distributed in knee and ankle joints. From this data it can be concluded, that the incidence of joint injuries and the injury pattern from the knee compared to the ankle does not correlate with the severity and frequency of cartilage damage and thus has no influence on the differential rate of osteoarthritis in both joints.

What are the new findings

The incidence of joint injuries and the injury pattern from the knee compared to the ankle does not correlate with the severity and frequency of cartilage damage.

The incidence of joint injuries and the injury pattern has no influence on the differential rate of osteoarthritis in knee and ankle joints.

How might it impact on clinical practice in the near future

On the basis of the injury pattern, no statement can be made regarding the frequency and severity of cartilage damage.

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