Twenty Years of Knee Dislocations

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Dan Wascher and I began our academic orthopaedic surgery careers around the same time: Dan here at the University of New Mexico (UNM) in 1991 and myself, Bob Schenck, at the University of Texas San Antonio in 1990. We had similar experiences, as we had been trained in knee ligamentous surgery (Dan at the University of California Los Angeles and me with Frank Noyes), and found that trauma-heavy institutions, at that time, treated knee dislocations (multi-ligamentous knee injuries) as an afterthought. Independently, we were able to publish information that although not quite the paradigm shift of antibiotic therapy, gave orthopaedic surgeons a new way to look at knee dislocations (KD). What we both discovered is the wide array of presentations that can be seen when 2 or more ligaments about the knee tear, and that the sports medicine approach may not always be the right approach. An initially more conservative approach to the management of torn knee ligaments can be determined after looking at the patient as a whole, especially with multi-trauma and the possibility of a closed head injury. Furthermore, the status of the neurovascular tree, as well as the soft tissue envelope, can quickly direct the clinician to a limb salvage procedure rather than a ligamentous reconstruction. We both learned that ligamentous reconstructions are challenging, and best performed in one setting where all injured structures are repaired if avulsed or reconstructed if torn in midsubstance. And we learned what Sisto and Warren preached about in their *Clinical Orthopaedics and Related Research* article on knee dislocations: a stiff reconstructed knee is worse than a mobile loose knee.[1]

This review is in part light-hearted, but I want to share with the young orthopaedic surgeon some of the process involved in advancing the field of any clinical academic study. There are challenges, and I would like to reflect upon two ideas Dan and I put together in learning about the patient with a dislocated knee.

First, Dan and Tom DeCoster's paper on the spontaneously reduced knee dislocation was a very creative approach to prove (or disprove) that knee dislocations often go unrecognized.[2] What is seen at presentation of the patient with a bicruciate ligament injury in the emergency room after a fall, motor vehicle accident, or sporting injury, is often relatively normally reduced radiographs of the knee. The concept of a spontaneously reduced knee dislocation was first introduced by Dan and Tom, and to further support that the knee was dislocated at some point in the injury, the risk of neurovascular injury was the same in the patient with a knee dislocated on plain radiographs as in the patient presenting with radiographs showing normal tibio-femoral alignment. Thus the trauma patient with the swollen knee, with relatively normal appearing tibio-femoral knee radiographs should be suspected of having dislocated the knee at one point in time.

An excellent case in point is a patient treated at UNM in 1993. He had suffered bilateral knee injuries after being pinned by a car against a wall. His right knee presented dislocated and his left knee was reduced on initial radiographs. Vascular evaluation revealed a transection of the popliteal artery on the reduced left knee. He underwent successful reverse saphenous vein grafting of the popliteal artery with simultaneous external fixation of his left knee. Three days later he had ligamentous reconstruction and repair of the ligamentous injuries to his right knee. Six weeks post-injury he underwent fixator removal from the left knee and at 12 weeks post-injury, he underwent bicruciate reconstruction of the revascularized left knee (Figure 1a-d).

Several authors have shown patients presenting with a completely dislocated knee but with tearing of only one cruciate ligament in case reports or small series. The anterior cruciate ligament (ACL)-intact knee dislocation was described by Dan Cooper and Russ Warren, and usually occurred with a completely torn posterolateral corner.[3] Thus, the use of the term "knee dislocation" didn't imply exactly which ligaments were torn. Dan's discovery of the spontaneously reduced knee dislocation shifted our description of these injuries as multi-ligamentous knee injuries, and on occasion, bicruciate injuries, to differentiate when both the ACL and posterior cruciate ligament (PCL) are torn. Dan and Tom discovered that 20% of their patients with a multi-ligamentous knee injury presented without any radiographic evidence that the knee was dislocated: that is, 20% were noted to have a spontaneously reduced knee dislocation.

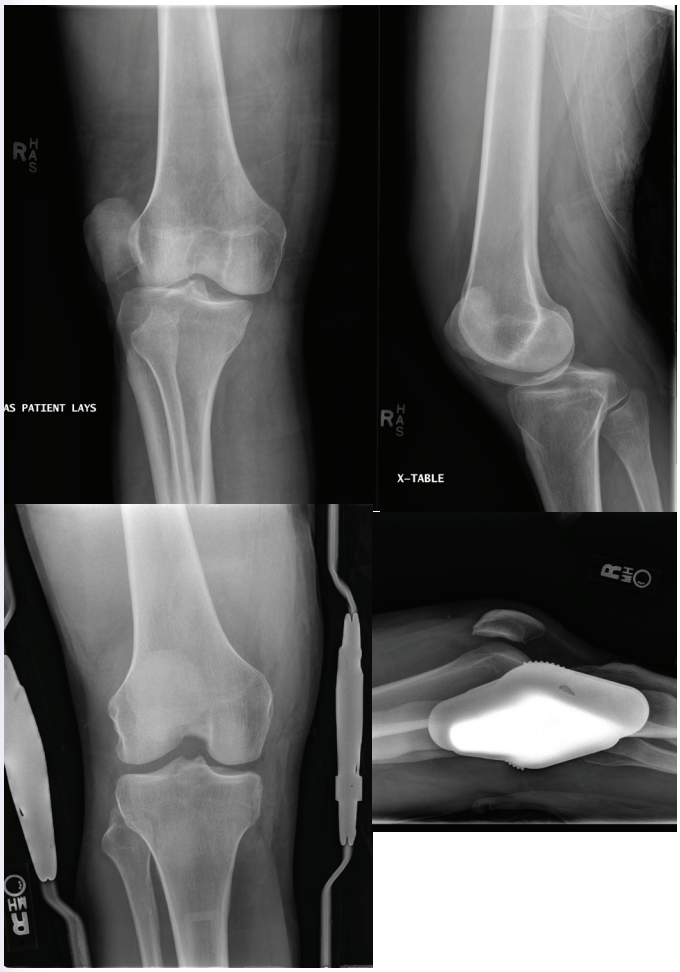

Figure 1a-d. Unstable KDIV which was easily closed reduced. While admitted noted increasing knee pain and radiographs revealed subluxation in the brace. Ex-fix versus operative repair considered.

Having been trained by Frank Noyes, I began describing sports knee injuries based on what is torn rather than the long-held view of specific instability patterns. This approach gave me an opportunity to look at KD in a different light. In the early 90s, patients with knee injuries were often described in terms of their pathologic laxity (e.g., anterolateral rotatory instability) rather than the anatomic structure torn. Describing a patient as having a complete ACL and complete medial collateral ligament (MCL) tear gave more accurate information on what was injured needing reconstruction rather than describing the abnormal motion pattern when examining the knee. Both clearly are important, but for descriptive purposes and determining what should be reconstructed, knowing which ligament(s) is (are) torn is paramount to the proper treatment of the unstable knee.

Thus it was a natural progression for me, as I began my KD practice in 1990, to look at which ligament was injured rather than which way the knee was dislocated. For 20 or more years prior to my starting practice, a knee dislocation was described by the position of the dislocated tibia condyles on the femur, (e.g., anterior or posterior). The position classification system was described by Dr. Kennedy, and is still very useful for reduction maneuver, as well as the complex or locked knee dislocation seen with a posterolateral position.[4] However, the position classification gives no information as to surgical planning and does not capture the "reduced" bicruciate knee injury.

I saw very distinctive patterns in my patients and realized there were a finite number of ligamentous injuries that could present. That led to my developing an anatomic classification system described in Table 1.[5] The system is based on an examination under anesthesia and on what is completely torn. Use of magnetic resonance (MR) has been a clear advantage, and KP Reddy and I published a small series of patients in 1996 which showed the usefulness of MR imaging in multi-ligamentous knee injury.[6] But MR overcalls some ligamentous injuries (sprain rather than completely torn); the anatomic system uses clinical examination of what is torn to determine how the knee is classified. Furthermore, using "C" or "N" with the KD numeric quickly conveys the neurovascular status of the patient. Dan came up with a KD V to describe the fracture-dislocation pattern of injury subcategorized by Tilman Moore.[7]

What is so interesting for the academic in me was the amount of time it took for the classification system to be accepted nationally and now worldwide. The original discussion of 13 patients ("A baker's dozen of knee dislocations") was rejected by the American Academy of Orthopaedic Surgery, American Orthopaedic Society for Sports Medicine (AOSSM), Journal of Bone and Joint Surgery, and American Journal of Knee Surgery. I was able to present it at the Western Orthopaedic Association and then published it in the *American Journal of Knee Surgery* in 1994.[5] It was only in 2000 that I was called by Bill Clancy asking me to explain the classification system, whereafter he presented it at the AOSSM and opined that it was the best system to use. It was only this past year when I saw the anatomic classification system described as "Schenck" that I chuckled at how many years it took-17. Our advice to the young academic surgeon is to find an area or areas of interest, extensively review the current state of knowledge based on the literature, study your patients, and be patient as you put forth ideas. Most importantly, get it in print, and as in my case, when Bill Clancy calls, pick up the phone!

Table 1

Anatomic classification of knee dislocations. "C" or "N" with the KD numeric denotes the neurovascular status of the patient.

Class	Injury
KD I	PCL or ACL intact knee dislocation
	Variable collateral involvement
KD II	Both cruciates torn, collaterals intact
KD III	Both cruciates torn, one collateral torn
	Subset M (medial) or L (lateral)
KD IV	All four ligaments torn
KD V	Periarticular fracture-dislocation

Abbreviations. C, arterial injury; N, nerve injury; KD, knee dislocation; PCL, posterior cruciate ligament; ACL, anterior cruciate ligament.

Dan and I began discussing our experience and approach to the dislocated knee at the AOSSM meetings in the late 90s. We had some similar approaches to these complex knee injuries and some differences of opinions. We learned from each other's experiences. This common interest in an unusual problem led to us becoming partners at UNM a few years later. Dan, Tom, and I encourage you to attend meetings and seek out others with a common practice focus. You never know where those connections may lead!

One interesting area is what Dan and I do differently. Our philosophical approach to the PCL is the same: restore what Jack Hughston referred to as "the cornerstone of the knee." But I had some failures early on with transtibial tunnels and performed my first PCL inlay in 1996. I modified Bob Burks' approach to avoid placing the patient in the prone position.[8] Exposure of the back of the tibia while the patient is prone is performed through the interval between the semi-tendinosis and medial head of the gastrocnemious. My modification was to use an "interval" between the posterior aspect of the MCL and pes anserinus (MCL and semitendinous), staying anterior to the gastrocnemius and taking down distal portions of the semi-membranosus. Flexing the knee to 90° while externally rotating the hip (unilateral frog leg position) allows the surgeon to clearly and safely visualize the back of the tibia while standing on the opposite side of the table. And I avoid flipping the patient.

Dan reconstructs the PCL through a transtibial approach and was one of the first to publish this technique using allografts.[9] His use of intraoperative radiographs and his procedure to avoid plunging with the reamer when making the tibial tunnel is technically outstanding. We would be remiss without mentioning Greg Fanelli in discussing this technique and long term follow-up of simultaneously reconstructed bicruciate knee injuries.[10]

The dislocated knee in the trauma patient deserves special discussion. The need to carefully evaluate and temper one's approach to the ligamentous problem is key to avoid infection, stiffness, or limb loss. Jim Stannard and others have described the usefulness of sequential clinical examination in a way to avoid arteriography in the patient with a normal clinical vascular exam.[11] Dan and I are grateful for this advance, but urge a low threshold for arteriography in the uncooperative patient (closed head injury), any evidence of assymetric vascularity, or an ankle brachial index below 0.9. But in the arena of the trauma team, there are usually many resources for consultation by vascular or the trauma service so the descision is by consensus. Certainly, following a normal vascular exam is clinically safe, but the clinician should review Dr. Stannard's original recommendations of repeated vascular checks for 48 hours.

In the area of multi-trauma, we have liberally used external fixation to aid in improved patient mobility, avoid pressure injury from splints in a neuro-compromised patient, maintain joint position in a grossly

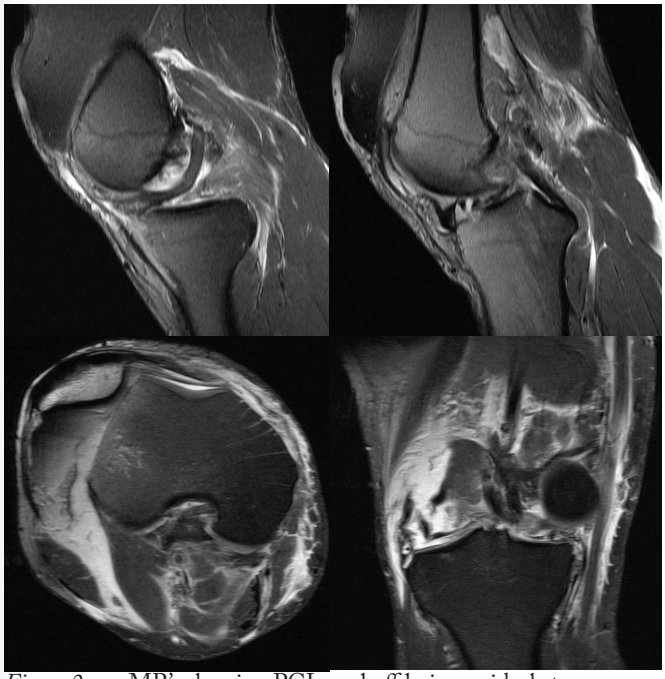

Figure 2a-e. MR's showing PCL peel off lesion, midsubstance ACL, femoral avulsion of posterolateral corner, midsubstance tear of superficial MCL, avulsion of MPFL from femur, locked medial and lateral meniscal tears. With locked meniscal tears felt open reconstruction would be needed for definitive stabilization.

unstable knee, and of course, in the patient with an open knee injury or one requiring revascularization. Tom, Deana Mercer, and I looked at the various external fixation constructs. We found the simplest frame to be one with anterolateral femoral pins in combination with anteromedial tibial pins.[12] Standard external fixation principles apply with the most stable constructs minimizing the bar-to-skin distance and maximizing the crossing bars (Figure 2a-d). External fixation is becoming more popular, as evidenced the recent report by Fred Azar et al. on low energy/morbid obesity knee dislocations. Their recommendation was for external stabilization of the tibio-femoral position in these patients.[13]

It is this mutual interest in knee dislocations that prompted us to obtain IRB approval to conduct a review of patients with knee dislocations who presented to UNM during an 8 year period and present preliminary data concerning the clinical outcomes of these patients after treatment, with a minimum 2 year follow-up. Using selected CPT codes and a trauma registry at UNM, patients were identified who sustained a KD between January 2000 and December 2007, ensuring a minimum 2 year follow-up. Dustin Richter, PGYII, began a retrospective chart review to identify mechanism of injury, injury pattern, associated neurovascular injuries, and treatment of this group of patients with a multi-ligamentous knee injury. Patients were contacted and are currently being evaluated using both subjective and objective measures. Subjective measures include the Lysholm, Tegner activity, VAS, SF-36, and IKDC questionnaires, and a psychosocial questionnaire. Objective measures include ligamentous examination by an independent observer (TN), radiographs to evaluate arthritis and stress radiographs to evaluate posterior laxity, and physical therapy assessment, including hop test, KT-1000 arthrometer, and strength testing utilizing an isokinetic dynamometer.

A total of 101 patients with 102 knee dislocations were identified. Three of these patients are deceased and 1 has a traumatic brain injury. Of the remaining 97 patients, the average age is 39 years (range 19-63) with 74 males (76%) and 23 females (24%). The following injury patterns were seen: 6% KD1, 1% KD2, 75% KD3 (21% KD3L, 54% KD3M), 4% KD4, and 14% KD5. Neurologic and arterial injury were seen in 10% and 4% of cases, respectively. Fifty-six percent of neurologic injuries were associated with a KD3L pattern and 75% of vascular injuries were associated with a KD3M pattern. Twenty-six patients are currently enrolled in the study and 16 have completed evaluation. The average age is 43 years and average time from surgery is 7.25 years. Subjective assessment average scores are: SF-36 physical health = 47.1, Lysholm = 75.6, IKDC = 69.2, VAS involved = 32mm, and VAS uninvolved = 15mm. Six patients have returned to heavy or competitive activity. Radiographic and functional testing results are being compiled. We found that the KD3M is the most common injury pattern seen and is associated with greater risk for vascular injury, whereas KD3L classifications have a higher rate of neurologic injury. Preliminary data shows that patients overall do fairly well post-operatively, with greater than one-third returning to heavy or competitive activity.

In summary, knee dislocations have been a great interest and challenge of ours for the past 20 years. We look forward to further information coming from the current study underway, possibly giving us more insight in the PCL inlay versus transtibial tunnel approach. We hypothesize there will be no difference in how one reconstructs the PCL, but will find improvement in outcomes depending on how well the PCL origin on the tibia is reestablished. We continue to look at the dislocated knee as one of multiple presentations requiring careful judgment in surgical management, and we all continue to learn about this complicated orthopaedic problem.

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