**Appendix 1**

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| **Meniscus tears** | | | | | | | | |
| **Incidence** | 6% of acutely injured knees sustain a meniscus tear (17); 0.3 to 1.1/1000 in kids with hemarthrosis (18-20) | | | | | | **Outpatient surgery** | |
| **Number of surgeons/assistants:** 2 or 3 | **Anesthesia:** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. Sedation + spinal or epidural (no need of ventilator) 3. Light sedation with local anesthetic (no ventilator) | | | **Surgical Time:** 30 to 60 minutes (47) | | | **Average Cost**: Repair $2872 ± 30%; meniscectomy $2732 ± 30% (49) to $6310 (21) | |
| **Short-term disability** | Dependent on presence of mechanical symptoms. Considerable disability when there is restricted ROM due to mechanical blockage of a displaced bucked-handle meniscus. Usually associated with significant pain and swelling. Surgery is needed to regain full ROM and to provide symptom improvement of ADL. Milddisability when pain is present in the absence of mechanical symptoms in a stable tear (small vertical tears of the posterior horn, horizontal tear, radial tears, and root tears). Usually patients can perform most ADL with few exceptions; for the most part patient is limited in sports and recreational activities. | | | | | | | |
| **Long-term disability** | Depends mainly on the subsequent risk of symptomatic arthritis, which depends on 1) knee compartment, 2) type of tear, and 3) treatment. Root tears, radial tears, and bucket-handle meniscus tears and respective meniscectomies result in larger increases in joint load and therefore increase risk of arthritis (22-25). Increased contact stress is directly related to the amount of meniscectomy: 24% (50% meniscectomy), 58% (75% meniscectomy), 128% (segmental meniscectomy), and 134% (total meniscectomy) (23). Because the lateral meniscus covers approximately, 75–93 % of the lateral tibial plateau while the medial meniscus covers slightly less (51–74 %), increases in contact stress are more pronounced in the lateral compartment (26, 27). Vertical longitudinal tears are more likely to heal than are other tear patterns, however, if the tear extends from the anterior horn to the posterior horn, allowing the meniscal fragment to flip on itself (a bucket-handle tear), the rate of healing is reduced (28, 29). The repair of horizontal cleavage tear and medial or lateral root tears restores peak contact pressures and knee mechanics (22, 24, 30). Patients with meniscus root repair have less arthritic progression (nonoperative, 1.0; partial meniscectomy, 1.1; meniscal repair, 0.1; P = .001) (31). Over 10 years, meniscus repair, meniscectomy, and nonoperative treatment in patients with meniscus root tears leads to 53.0%, 99.3%, and 95.1% rates of OA, respectively; and 33.5%, 51.5%, and 45.5% rates of TKA, respectively (32). Surgical treatment of degenerative tears is controversial, non-operative treatment is the first line treatment, even in the setting of mechanical symptoms for at least 6 weeks (33, 34). Some studies show similar mid-term results with non-operative and operative treatment (34, 35). | | | | | | | |
| **Time sensitivity** | It’s dependent on the degree of short-term and long-term disability and potential for meniscus repair. Meniscus reparability depends on a variety of factors including the type of tear and patient’s age. It is further indicated in patients < 40 years old, however it has similar results in this population as to patients < 40 years old (36). Vertical tears, bucket-handle, horizontal tears, radial tears, and root tears can be successfully repaired while complex tears and flaps cannot (37-42). Reparability can be predicted by MRI, with a sensitive and specificity > 0.8 in various studies (43, 44). It is more likely when the distance measured from the tear to the menisco-capsular junction is < 4-5 mm (43, 44), tear is > 1cm (43, 54) and there is generation of isosignals by the inner meniscal fragment and peripheral rim compared with the normal contralateral meniscus of the same knee (43). Failure rate of repairs of bucket-handle tears are between 17% and 29% (39, 47). Regarding effect of timing of surgery on outcome scores there is some inconsistency. For vertical, horizontal of bucket-handle tear (isolated or with ACL reconstruction), meniscus repair leads to better outcomes when performed in < 6 weeks (45). One study found that patients treated in < 1 week had better outcomes than patients treated > 1 week (48). Conversely, one study found no differences in healing rates between acute (< 2 weeks), subacute (> 2 to < 12 weeks), and chronic (> 12 weeks) treatments (46). The repair of meniscus root tears results in a decrease of progression to TKA when performed in < 6 months (41). The treatment of degenerative meniscus tears or ones that cannot be repaired can safely be delayed without long-term disability consequences. | | | | | | | |
| **Cost effectiveness** | Knee arthroscopy (including meniscectomy and meniscus repair) have been shown to be cost effective, cost per QALY is $5,783 (21). Meniscal repair is associated with an increased failure rate (RR of 4.37), but meaningful reductions in OA and TKA incidence (29.7% vs. 39.4% and 19.6% vs. 27.9%, respectively) (49). Over a 30-year horizon, meniscal repair has overall discount savings of $2,384 compared to meniscectomies. In addition, tax payers could save approximately $43 million annually if 10% of current meniscectomies were meniscus repairs (49). When looking specifically at meniscus root repairs, 10- year costs are $22,590 for meniscus repair, as opposed to $31,528 and $25,006 for meniscectomy and nonoperative treatment (32). Similar results were seen in regard to meniscus repair in the setting of ACL reconstruction (55) | | | | | | | |
| **Risk for COVID-19 complications** | The typical patient who has an acute traumatic meniscus tear and undergoes a repair is a young and healthy patient who has low risk for complications (50). In addition, surgery is performed with a short hospital stay, further decreasing the risk. | | | | | | | |
| **Risk for surgical complications** | Meniscectomy = 2.8% (52) and meniscal repair = 2.4%-7.6% (51, 52). Most complications can be treated clinically in an outpatient setting, 30-day reoperation and readmission rates are 0.4% and 0.64% respectively (53). | | | | | | | |
| **Post-surgical needs** | Low, home exercises can be performed in the first 1-2 weeks and PT is needed once a week afterwards. Wound care is simple and can be monitored by the patient and telehealth. | | | | | | | |
| **Social/home support** | Generally low need for home support after the first several days, particularly in the case of young patients that are independent for their ADL. Patients may be dependent on others for outside activities such as doctors’ appointments and PT. | | | | | | | |
| **Anterior Cruciate Ligament Reconstruction** | | | | | | | | |
| **Incidence** | 100,000-200,000 ACL rupture/year; 1:3500 in general population; 64% cutting/pivoting injuries | | | | | | **Outpatient surgery** | |
| **Number of surgeons/assistants:** 2 or 3 | **Anesthesia:** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. Sedation + spinal or epidural (no need of ventilator) | | | **Surgical Time:** 94.62 minutes (range 60-125 min) (56) | | | **Average Cost**: $1.7 billion annually; Median immediate procedure cost was $9399.49. Median total health care utilization cost was $13,403.38. | |
| **Short-term disability** | Dependent on concomitant injuries, including displaced meniscus tear and/or chondral injury with loose body. Multiple ligament injury considered separately. If there is an isolated ACL tear, patients present with pain and swelling, which improves with conservative management within a few days to weeks. Patients can then develop symptoms of instability, especially for cutting and pivoting sports activities. ADL are usually well tolerated with minimal limitations. | | | | | | | |
| **Long-term disability** | Depends mainly on the subsequent risk of symptomatic arthritis; Research demonstrates that adolescents and young adults who sustain an ACL injury are at a substantially increased risk for the development of future OA in the patellofemoral and tibiofemoral joints Subchondral sclerosis, meniscal degeneration, and osteochondral defects are also commonly observed in the chronic ACL-deficient knee. Some studies suggest that as many as 80% of ACL injured knees may demonstrate radiographic evidence of OA at 5 to 15 years after initial injury, especially with concomitant meniscal damage. While injury to knee articular cartilage, menisci, and/or other ligaments is thought to contribute to the development of OA in the ACL-deficient knee, secondary injury due to instability and alterations in the normal biomechanics of the knee is also thought to play a role in the development of OA. | | | | | | | |
| **Time sensitivity** | An ACL deficient knee increases the risk of new cartilage and meniscus injuries. The odds of a cartilage lesion in the adult knee increases by nearly 1% for each month that elapsed from the injury date until the surgery date (57). If there is a meniscus tear, the meniscus dictates urgency. Not only is the reparability of the meniscus influenced by the time from injury, but also in an ACL tear, the odds of having a cartilage lesion are twice as high if there is a concomitant meniscal lesion, and vice versa (57). Other studies have shown an increased risk of medial meniscus injury (6–12 months: OR = 1.81; and 12 months: OR = 2.19) with increasing time to ACLR(58). Early (within 3-5 months from injury) versus late (after 3-5 months from injury) ACL reconstruction may improve objective knee stability and result in higher activity level (59). However, this is controversial as another study showed no difference in strength and knee stability between them. In addition, performing reconstruction within three weeks of injury, increases the rate of re-operation from 0% to 8% (60). Delayed ACL reconstruction (≥90 days) among patients aged ≥40 years is not associated with an increased risk of meniscal or chondral injury, however if >1 year, it is associated with increased risk of medial meniscal tear (61). Therefore, ACL reconstruction is likely more time sensitive in younger patients than in older patients and can be performed in 3-6 months in younger patients and 6-12 months in older patients. | | | | | | | |
| **Cost effectiveness** | Knee arthroscopy has been shown to be cost effective; cost per QALY is $5,783(21)  The incremental cost-effectiveness ratio of ACL reconstruction compared with PT was $22,702 per QALY gained. The ICER was most sensitive to the quality of life of returning to play or not returning to play, costs, and duration of follow-up(62). Similar cost-effective results were seen in regard to meniscus repair in the setting of ACL reconstruction(55). | | | | | | | |
| **Risk for COVID-19 complications** | The typical patient who has acute ACL tear that undergoes reconstruction is a young and healthy patient who has low risk for complications. In addition, surgery is performed as an outpatient, further decreasing the risk. | | | | | | | |
| **Risk for surgical complications** | In a study of 104,255 procedures using the National Hospital Episode Statistics Database for England, UK; within 90 days, serious complications occurred in 675 (0.65% [95% CI, 0.60-0.70]), including 494 reoperations for infections (0.47% [95% CI, 0.43-0.52]) and 129 for pulmonary embolism (0.12% [95% CI, 0.10-0.15]) (63). | | | | | | | |
| **Post-surgical needs** | Low, home exercises can be performed in the first 1-2 weeks and PT is needed once a week afterwards. Wound care is simple and can be monitored by the patient and telehealth. | | | | | | | |
| **Social/home support** | Generally low need for home support after the first several days, particularly in the case of young patients that are independent for their ADL. Patients may be dependent on others for outside activities such as doctors’ appointments and PT. | | | | | | | |
| **Extensor mechanism (patellar tendon and quadriceps tendon) rupture** | | | | | | | | |
| **Incidence** | They are rare injuries, with an incidence of 1.37/100,000 per year for quadriceps tendon ruptures (QTR) and an incidence of 0.68/100,000 per year for patellar tendon ruptures (PTR)(64) | | | | | | **Outpatient surgery** | |
| **Number of surgeons/assistants:** 2 or 3 | **Anesthesia:** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. Sedation + spinal or epidural (no need of ventilator) | | **Surgical Time:** 60 to 120 minutes | | | **Average Cost**: Not reported in the literature | | |
| **Short-term disability** | Patients with partial tears have a competent extensor mechanism (can fully actively extend the knee against gravity) while patients with complete tears do not. Therefore, patients with partial tears can be treated non-surgically, with immobilization and crutches for 6 weeks (65, 66). Meantime, patients with complete tears have severe short term disability by limited ambulation, being dependent on the use of brace and crutches. | | | | | | | |
| **Long-term disability** | Patients with complete tendon tears that are not repaired tend to regain passive ROM within a few weeks (74); however, they continue to lack full active knee extension and to depend on walking aids. Complete tears have poor outcomes when treated non-surgically and good to excellent outcomes after acute surgical repair (66-70). | | | | | | | |
| **Time sensitivity** | Acute tears can be treated by primary reinsertion of the tendon on the patella or side to side sutures. With a patellar tendon tear the patellar is pulled proximally causing patella alta and with a quadriceps tendon tear the patella migrates distally causing patellar baja. With time, the intact remaining soft tissue extensor mechanism (muscle and tendon) retract and contract resulting in a fixed patella alta or baja (one that cannot be reduced); this process starts as soon as 2 weeks (66). Therefore, chronic tears (2-6 weeks) have a higher likelihood of requiring lengthening of the retracted/contracted tendon, augmentation or a complete reconstruction (66, 68, 71-78). Many techniques have been described for augmentations and reconstructions of extensor mechanism ruptures, including synthetic ligaments, semitendinosus autograft, Achilles allograft and patellar tendon allograft (66, 68, 74, 76, 79, 80). Repairs performed in < 2-3 weeks have consistently good results and time from injury does not appear to influence outcomes within this timeframe (67, 72) However, patients with chronic tears that are repaired or reconstructed seem to have less successful outcomes (e.g. increased extension lag, more weakness and decreased flexion) compared to acute tears (67, 71-73, 81-84). | | | | | | | |
| **Cost effectiveness** | This has not been studied, but if the extensor mechanism remains defective, long term disability will set in as normal ambulation will be hindered. This can lead to increased health care costs to deal with the disability. It is therefore expected that, when needed, it is cost-effective to surgically address extensor mechanism rupture in an appropriate time frame. Traditional transosseous sutures have been reported as more cost-effective than suture anchors for repair of quadriceps tendon rupture, although more invasive and associated with a longer hospital stay(86). | | | | | | | |
| **Risk for COVID-19 complications** | Patients with quadriceps tear tend to be older (59.8 ± 15.2 years) than patients with patellar tendon tears (42 ± 15.7 years)(69). Patients with quadriceps tendon or patellar tendon tears can have associated comorbidities (renal failure gout, diabetes, rheumatoid arthritis, hyperparathyroidism, connective tissue disorders) (66, 68). In addition, patellar tendinitis is a risk factors for patellar tendon tears (68, 85). Therefore, patients can have a higher risk for COVID-19 complications. | | | | | | | |
| **Risk for surgical complications** | Wound healing disorders/septic complications occur in 8% of the QTR- and 13% of the PTR (69). | | | | | | | |
| **Post-surgical needs** | Low, home exercises can be performed in the first 3-6 weeks and PT is needed once a week afterwards. Wound care is simple and can be monitored by the patient and telehealth. | | | | | | | |
| **Social/home support** | Generally low to moderate depending on patients’ health status. Patients may be dependent on others for outside activities such as doctors’ appointments and PT. | | | | | | | |
| **Patellar dislocation** | | | | | | | | |
| **Incidence** | Acute first time lateral patellar dislocation = 23.2-42/100,000 person-years; 2.3% undergo surgery for acute osteochondral injury; 22.7%-36.0% risk of recurrent dislocation. (87-90) | | | | | | **Outpatient surgery, some surgeons will admit overnight for TTO** | |
| **Number of surgeons/assistants:** 2 | **Anesthesia** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. Sedation + spinal or epidural (no need of ventilator) | | | **Surgical Time:** 30 to 60 minutes (47) | | | **Average Cost**: Osteochondral fracture repair; MPFL repair or reconstruction; TTO, each: $2744 or $5699 (surgical center vs hospital outpatient department, respectively) (91) | |
| **Short-term disability** | Disability from a patellar dislocation is based on the presence of 1) size and displacement of osteochondral fracture and 2) progression to recurrent instability. A large displaced osteochondral fracture can cause mechanical symptoms and restrict ROM. First time patellar dislocation without large osteochondral fracture presents with pain and swelling, which improves with conservative management. Risk of recurrent dislocation is reported as 22.7%-36.0%, with increased risk in trochlear dysplasia (odds ratio 18.1), age <18 years at time of first dislocation (odds ratio 2.4), TTTG distance >=20mm (odds ratio 2.1) and female sex (odds ratio 1.5) (87, 90, 111). Patients with three or more risk factors have a recurrence rate of 70-80% (92). Time to redislocation was decreased in patients with trochlear dysplasia, TTTG>=20mm, patella alta with Caton Deschamps Index >= 1.3, and age <18 (90). Recurrent instability (symptoms after conservative treatment) can cause giving way of the knee. Depending on the severity, this can occur with ADL or be limited to recreational and sporting activities. Patients with recurrent patellar instability have significant improvement in symptoms and quality of life after operative treatment and rates of redislocation are < 10% when MPFL reconstruction is performed and all severe risk factors are addressed (93-96). | | | | | | | |
| **Long-term disability** | Patients who sustain patellar dislocation are at high risk for progressing to patellofemoral arthritis, with a reported rate of 48.9% at 25-year follow-up. Recurrent patellar instability (HR 4.5), osteochondral injury (HR 11.3), and the presence of trochlear dysplasia (HR 3.6) were associated with increased risk of arthritis after patellar dislocation (111). Fixation of osteochondral lesions particularly in weight bearing areas, can potentially decrease the risk of arthritis. | | | | | | | |
| **Time sensitivity** | Timing of surgery is dependent on factors related to 1) the presence and size of a displaced osteochondral or chondral fracture, and 2) recurrence of instability, as noted above. In the case of first-time patellar dislocation without chondral or osteochondral fracture, initial conservative management can be utilized. There is growing discussion surrounding risk stratification and consideration of early surgery in those with multiple risk factors for recurrence(97, 98); however, this should be addressed in a case-specific manner. In general, acute surgical intervention in the case of first-time patellar dislocations has been reserved for those with large, displaced osteochondral or chondral fractures. It is recommended that large osteochondral fragments with a bony base be acutely repaired (99, 100). Controversy lies with cartilage only fragments that are traditionally believed to not heal successfully. However, recent reports of patients in which acute (most < 2 weeks) traumatic cartilage only fragments were successfully repaired with bioabsorbable implants, allowing all patients to return to sports, supports the notion that these should be fixed acutely (1-2 weeks) (101). Smaller fragments (approximately <1cm) can often be treated conservatively as they can be less likely to cause mechanical symptoms or be viable for repair. Little data exists on outcomes related to the timing of patellar stabilization surgery in the current literature. One study showed no differences in outcome related to the time from the first dislocation to stabilization procedures(102); however, the modifiable risk factors for long-term disability, including osteochondral fracture and recurrent dislocations, should be addressed. | | | | | | | |
| **Cost effectiveness** | Nonoperative treatment of patellar instability is the least costly ($7300) but the least effective (5.30 QALYs). Initial nonoperative treatment with delayed surgery is $10,500 with a 5.93 QALY benefit. Immediate surgery is $17,100 with a 6.32 QALY benefit. When comparting nonoperative treatment to initial nonoperative treatment with delayed surgery, the ICER was $5100/QALY. Immediate vs delayed surgery ICER is $17,000 per QALY. When the probability of achieving recovery with nonoperative treatment is > 47.5% (as in cases of first time patellar dislocation with no osteochondral fracture and minimal risk factors), initial nonoperative treatment with delayed surgery is preferred to immediate surgery.(103). | | | | | | | |
| **Risk for COVID-19 complications** | Acute patellar dislocation is most common in adolescents(87, 90), who generally are reported to be at low risk for complications related to COVID-19 (50). | | | | | | | |
| **Risk for surgical complications** | Complication rates vary by the procedure performed. MPFL reconstruction (26.1%; (104) includes: patella fracture, recurrence of instability, loss of ROM, and wound complications(104-106)). TTO: painful hardware (up to 77%) and need for removal, 5% recurrent instability, 1-3% rate of tibial fracture, 1% rate of nonunion, and 1% deep wound infections (107, 108). The risk of DVT (4%) is reported to be higher than in other sports medicine surgeries(107, 109). In the cases of osteochondral fracture fixation, removal of metal implants are required typically 6 weeks after fixation, however absorbable fixation methods can be used to avoid this need(110). In the case of loose body removal with chondral biopsy, a second stage surgery is often required for autologous chondrocyte implantation, but this can be performed as an elective surgery. | | | | | | | |
| **Post-surgical needs** | Moderate. Home exercises can be performed in the first 1-2 weeks and PT is needed twice weekly after that. Wound care is simple and can be monitored by the patient and telehealth. In the case of osteochondral fixation or TTO, postoperative imaging may need to be obtained (until healing, first 6 to 12 weeks) to determine weight bearing status and activity levels. | | | | | | | |
| **Social/home support** | Generally low need for home support after the first several days, particularly in the case of young patients that are independent for their ADL. Patients may be dependent on others for outside activities such as doctors’ appointments and PT. | | | | | | | |
| **Osteochondritis Dissecans** | | | | | | | | |
| **Incidence** | 3.42-6.09/100,000 person-years (112, 113) | | | | | | **Outpatient surgery** | |
| **Number of surgeons/assistants:** 2 or 3 | **Anesthesia** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. Sedation + spinal or epidural (no need of ventilator) 3. Light sedation with local anesthetic (no ventilator) | | | **Surgical Time:** 30 to 60 minutes | | | **Average Cost:** Not reported in the literature | |
| **Short-term disability** | Dependent on presence of mechanical symptoms. Considerable disability when there is restricted ROM due to mechanical blockage of a displaced osteochondral fragment. Usually associated with pain and swelling. Surgery often needed to provide symptomatic improvement for ADL, and to avoid damage to other areas of cartilage. Minimal short-term disability if there is a stable lesion or no loose body symptoms. Usually patients can perform most ADL with few exceptions; for the most part the patient is limited in sports and recreational activities. | | | | | | | |
| **Long-term disability** | Depends mainly on the state of the articular surface. If there is a loose body and that results in damage to other areas of the articular cartilage, then that increases the risk for OA in the long term. OCD fragment excision vs. surgical restoration has been shown to increase the risk of subsequent OA and TKA (114). So, if a fragment is unstable, but salvageable and it is not preserved, then there is an unnecessary increased risk of arthritis. The majority of patients undergoing fixation and preservation of an unstable OCD go on to heal, with good functional outcomes (115, 116). | | | | | | | |
| **Time sensitivity** | The most time sensitive states for OCD are in the case of loose bodies and unstable, but salvageable OCD lesions. In the case of loose OCD fragments, this is time sensitive because of the short-term disability, the chance for damage to other areas of articular cartilage, and the reduced ability to restore the fragment if not addressed quickly. In the case of unstable, but salvageable OCD lesions where the patient often presents with catching/locking, swelling, or pain, the fragments can go on to become loose bodies if not addressed quickly, leading to the issues mentioned above. In the case of unstable, but salvageable OCD lesions, imaging findings often suggest a break in the cartilage (117). In either case, surgery would ideally be performed within 4-6 weeks of presentation. | | | | | | | |
| **Cost effectiveness** | Has not been directly studied. A recent article highlighting health utility in several OCD lesion states demonstrated low health utility scores, suggesting that OCD has significant impact on patient health (118). | | | | | | | |
| **Risk for COVID-19 complications** | The typical patient who has symptoms from OCD is a young and healthy patient who has low risk for complications (50). In addition, surgery is performed with outpatient surgery, further decreasing the risk. | | | | | | | |
| **Risk for surgical complications** | 0-16%, primarily related to unplanned re-operation (119-121). | | | | | | | |
| **Post-surgical needs** | Low, home exercises can be performed. Often, once a week PT is sufficient and can potentially be done via telehealth. Wound care is simple and can be monitored by the patient and telehealth. | | | | | | | |
| **Social/home support** | Low, usually young patients that are independent for majority of ADL at home, however dependent on others for outside activities such as doctors’ appointments and PT. | | | | | | | |
| **Post-operative arthrofibrosis** | | | | | | | | |
| **Incidence** | 2-22% following ACL reconstruction; not well studied in other areas of sports medicine (122, 123) | | | | | | **Outpatient surgery** | |
| **Number of surgeons/assistants:** 2 | **Anesthesia** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. Sedation + spinal or epidural (no need of ventilator) 3. Light sedation with local anesthetic (no ventilator) | | | **Surgical Time:** 10 minutes if manipulation under anesthesia; 60 to 120 minutes is arthroscopic lysis of adhesion (most common) (124) | | | **Average Cost:** Not reported in the literature | |
| **Short-term disability** | Decreased ROM is present with arthrofibrosis and will persist long term if not addressed. Initial post-operative stiffness following surgery can often be addressed with dedicated PT and diligence on the part of the patient. In some cases, however, the arthrofibrosis develops and does not respond to rehabilitation. It is usually associated with pain. | | | | | | | |
| **Long-term disability** | Patients with long term motion deficits due to post-operative arthrofibrosis are at higher risk of early OA and have lower scores on PROs (124, 125). | | | | | | | |
| **Time sensitivity** | Concern for arthrofibrosis should be identified by 6 weeks and aggressive intervention initiated. If the arthrofibrosis fails to respond to non-surgical treatments, then earlier surgical intervention will result in improved outcomes (124). Generally, the best timeline for surgical intervention is within the 6-12 week post-operative period (124). | | | | | | | |
| **Cost effectiveness** | This has not been well studied, but if arthrofibrosis persists and there are long term disabilities, then it can lead to increased health care costs to deal with the disabilities. It is therefore expected that, when needed, it is cost-effective to surgically address arthrofibrosis in an appropriate time frame. | | | | | | | |
| **Risk for COVID-19 complications** | There is not a clearly defined patient who develops arthrofibrosis, some patients are young with no comorbidities while others are higher risk. Surgery is generally performed as an outpatient procedure. | | | | | | | |
| **Risk for surgical complications** | The re-operation rate following surgery for arthrofibrosis may be as high as 10% (124, 126). Other complications are low. | | | | | | | |
| **Post-surgical needs** | Moderate. CPM is usually used. PT is critical in the immediate post-operative state and generally best done in person, but could be partially done via telehealth. | | | | | | | |
| **Social/home support** | The needs are low, however having family members to help with the rehabilitation can improve the outcomes. | | | | | | | |
| **Multi-ligament injuries** | | | | | | | | |
| **Incidence** | 0.072 KDs per 100 patient-years (127) however the true incidence is unknown because they may be misdiagnosed as ~50% reduce before presentation(128, 129). The majority of high energy injuries are related to motor vehicle accidents (25.1%) and sporting activities (44.2%)(130). Injury to 3 major ligaments is the most common (KD III-M constituting 52.4%, KD III-L comprising 28.1% (130). Peroneal nerve injuries rate is 19.2 % of the patients (10.9% partial and 8.3% complete deficit). Vascular injuries from 5% to 23-32%, especially when associated with blunt trauma and motor vehicle accidents (129, 131) | | | | | | **Outpatient surgery vs inpatient, depending on soft tissue and neurovascular status** | |
| **Number of surgeons/assistants:** 2 or 3 | **Anesthesia** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. Sedation + spinal or epidural (no need of ventilator) | | | **Surgical Time:** 60 to 180 minutes | | | **Average Cost:** Highly variable depending on ligaments involved, use of allografts, implants and assistants. | |
| **Short-term disability** | Dependent on presence of neurovascular injury and soft tissue compromise. It is an emergency when there is limb/life threatening due to vascular injury or extensive soft tissue damage that could result in compartment syndrome. Early intervention and artery repair are performed along with knee stabilization with an external fixator. Nerve injury should also be addressed sooner rather than latter if a compressive origin is suspected. If no neurovascular injury is diagnosed, short-term disability depends on the degree of instability. Patients with grossly unstable knees (3 to 4 ligaments with high-grade or complete tear) have instability symptoms even for ADL despite non-operative treatment (brace and PT) while patients with less severe injuries (2 to 3 ligaments with partial tears) can have moderatedisability and improved comfort with non-operative treatment. Patients should work on regaining ROM and improving strength to maximize their possibilities to enhance their surgical outcomes if indicated. Ultimately, surgical treatment of the torn ligaments in multi-ligament injured knees can significantly improve PROs(132-134). In a meta-analysis, Dedmond et al. reported improved motion and Lysholm scores in the surgical treatment group.(132) . | | | | | | | |
| **Long-term disability** | Depends mainly on the subsequent risk of the possibility of repairing neurovascular injuries, the initial soft tissue damage and if present and symptomatic arthritis. The long-term negative effects of knee laxity on cartilage and menisci injuries has also been reported.(135-138) The cause of OA is probably multifactorial; including the injury mechanism itself, meniscal and chondral pathology, persistent instability after surgical treatment and joint overconstraint after ligament reconstruction. Rates of radiographic arthritis after KD can be as high as 42% (139) compared to 6% on the non-injured knee. Twenty-three percent of the patients have low grade (KL grade II) OA on the injured knee, while 5% have KL grade IV, although, not all of these patients were symptomatic.(140, 141) Patients older than 30 years at the time of surgery had a significantly higher risk of developing OA. In addition, patients treated surgically are less likely to develop severe radiographic degenerative changes (47.4%) versus patients treated non-operatively (88%) (142) | | | | | | | |
| **Time sensitivity** | Timing of surgery during multi-ligament injuries differs based on the soft tissue and neurovascular compromise which can make this an emergent indication as it can be life or limb threatening. For non-emergent indications, some authors have used 3 weeks as the critical time to better identify and treat the structures before scar tissue forms, making dissection and identification of the structures difficult, and tissue necrosis that can significantly affect outcomes.(143-146) Studies have reported superior outcomes in acutely treated patients compared to chronic treated patients and therefore when possible surgeries should be performed within 3 week if appropriate ROM has been achieved.(147, 148) In high energy trauma, surgery may be delayed because of injuries to the soft tissue about the knee and concomitant injuries to other vital organs. Furthermore, prolonged surgery time due to the treatment of concomitant injuries in a multi-traumatized patient with multi-ligament injuries provides an argument against single-stage surgery. However, stiffness in these patients may be easier to treat than recurrent instability. Therefore, it is important when treating patient with KD to adapt the treatment to the patient, conditions and setup of the hospital. However, single stage surgery should be the goal whenever possible. | | | | | | | |
| **Cost effectiveness** | No formal study has been performed. It is highly variable as it depends on the number of ligaments to be reconstructed, usage of allograft vs autografts, implants, surgical time and hospital stay. | | | | | | | |
| **Risk for COVID-19 complications** | The typical patient who has acute traumatic tears in the setting of sports activities has low risk for complications (50) . Moatshe et al(130) reported that the mean age at injury was 37.8 ± 15.3 years meaning that the majority of these patients will not be high risk COVID patients. | | | | | | | |
| **Risk for surgical complications** | Complications after multi-ligament injury are common regardless of their treatment.(149) Postoperative complications include persistent pain requiring frequent clinic visits, reoperations, stiffness, wound infections, compartment syndrome, residual instability, DVT, vascular claudication, and pulmonary embolism. | | | | | | | |
| **Post-surgical needs** | PT 3 times a week for the first 3 months. Wound care is simple and can be monitored by the patient and telehealth. | | | | | | | |
| **Social/home support** | Needs basic assistance at home to be able to carry out ADL. | | | | | | | |
| **Rotator Cuff Tears** | | | | | | | | |
| **Incidence** | 23% of acutely injured shoulders after trauma (150); 20.7% incidence in the general population (151) | | | | | | **Outpatient surgery, 1% chance of admission** | |
| **Number of surgeons/assistants:** 1 or 3 | **Anesthesia** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. General + regional (interscalene block) 3. Sedation + regional (interscalene block) | | | **Surgical Time:** 77 to 145 min (152, 153) | | | **Average Cost** $8,985(152) to $25,353(154) | |
| **Short-term disability** | Shoulder pain and weakness are the major symptoms after both traumatic and degenerative rotator cuff tears(155). Pseudoparalysis is a common finding after an acute traumatic injury that creates a massive, multi-tendon rotator cuff tear(156). Surgery is performed to control pain and regain ROM in both acute and chronic scenarios. For individuals in which a large or massive rotator cuff tear occurs as a result of an episode of shoulder dislocation, tendon repair also is aimed to treat shoulder instability and prevent further episodes of dislocation or subluxation (156-158). | | | | | | | |
| **Long-term disability** | Chronic and degenerative rotator cuff tears enlarge over a relatively short time. About 48% to 61% of rotator cuff tears enlarge after 1.5 to 2.8 years, and activity levels seem to influence tear progression (159-162). An increase in pain and dysfunction is associated with enlargement of the tear, with partial-thickness tears converting in a full-thickness tears, and full-thickness tears increasing in tear-size dimensions. Moreover, muscle degeneration, which ultimately influences healing rates and strength (163, 164), is associated with the enlargement of tendon tears over the years (159). Traumatic rotator cuff injury often results in massive tears that are especially susceptible to muscle degeneration and atrophy within a few weeks (156, 165). Additionally, chronic and massive rotator cuff tears left untreated may progress to rotator cuff arthropathy, which requires a more complicated and costly treatment. | | | | | | | |
| **Time sensitivity** | After an acute and traumatic rotator cuff tear, best available evidence suggests that early repair achieves better outcomes as compared to late repairs(156-158, 166-170)Although it is difficult to identify a therapeutic window or ideal timing in which acute and traumatic rotator cuff tears need to be repaired in order to achieve superior outcomes(172), repairs earlier after injury, in general, outperform late repairs. There are several retrospective case-control studies in the literature that used different timing after the injury to compare outcomes after repair. While some studies compare repairs within and after three weeks after trauma (157, 171), others used six weeks(167), 60 days(166), 3 months(172), 16 weeks(169), or six months(170) as timepoints to differentiate early from late repairs. Conversely, despite the vast majority of studies favoring early repairs, some cohorts were unable to identify differences in outcomes between surgeries occurring within 3 months(173), 16 weeks(169), or six months(170). Particularly for the subscapularis tendon, a full-thickness tear that occurs as a result of trauma shows that delayed treatment leads to irreparable tears with irreversible dysfunction and poor outcomes, and hence, these tears should be repaired as early as possible (167, 168, 174). Alternatively, operative treatment of degenerative tears or as a result of shoulder impingement or degeneration can safely be delayed for a few months without long-term disability consequences. | | | | | | | |
| **Cost effectiveness** | Rotator cuff repair has shown to have an essential role in minimizing the societal burden of rotator cuff disease(166). A Markov analysis using outpatient data from several states within the United States for Medicare reimbursements and best available evidence for outcomes and complications revealed that rotator cuff repair, as compared to nonoperative treatment, is both cost-saving for society in younger patients and cost-effective for all age groups(175). In other words, this means that surgery results in net societal savings for patients up to 61 years of age, and for the population over 70 of age, results in a cost of $36,576 per QALY. The mean difference regarding effectiveness between operative and nonoperative treatment was 0.62 QALY, and lifetime age-weighted mean total savings per patient was $13,771. | | | | | | | |
| **Risk for COVID-19 complications** | Considering that the average age for patients undergoing rotator cuff repair is 60.6 years for females and 56.1 years for males(176), this population presents a moderate risk for hospitalization if they develop COVID-19. However, a short hospital stay required for this procedure minimizes this risk. | | | | | | | |
| **Risk for surgical complications** | The overall complication rate for rotator cuff repairs is 1.3% (medical complications 0.3%, surgical site infections 0.1%, hospital admission 1.1%, discharge other than home 0.7% and mortality 0.1%)(177). 30-day readmission rate is 1%, and the most common complications associated with readmissions were cardiovascular (29%), infection (29%), and respiratory (17%)(178). Age > 65 years old was found to have twice the rate of complications as compared to patients under 55 years old(179). | | | | | | | |
| **Post-surgical needs** | Low. Home exercises can be done in the first four weeks, and PT may be needed after that period. Wound care can be monitored by the patient and on telehealth visits(180, 181). | | | | | | | |
| **Social/home support** | Since the vast majority of postoperative protocols entails the use of a sling for 4-6 weeks, patients might need some form of assistance at home for performing ADL. | | | | | | | |
| **Acromioclavicular Joint Separation** | | | | | | | | |
| **Incidence** | Up to 9% of all shoulder injuries (182).The majority of AC joint injuries (44%) occur in people in their twenties and are five times more common in men than in women (182). Most injuries (type I-III) are treated non-operatively, but surgical repair/reconstruction is recommended for type IV-VI. (183-187) | | | | | | **Outpatient surgery** | |
| **Number of surgeons/assistants:** 2 or 3 | **Anesthesia** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. General + regional (interscalene block) 3. Sedation + regional (interscalene block) | | | **Surgical Time:** 32 -80 minutes (188, 189) | | | **Average Cost:** Estimated $4,000-8,000, however published United States hospital cost data is limited (189, 190) | |
| **Short-term disability** | Associated with significant pain, swelling, deformity, and loss of ROM. Lower grade (type I-III) injuries are much more tolerable and, in most instances, treated non-operatively. Usually patients can perform most ADL with few exceptions. Activities which require overhead motion are the most difficult to perform. Although rare, subcoracoid displacement (type-VI) can cause paresthesias and neurovascular injury. | | | | | | | |
| **Long-term disability** | Long-term disability is dependent on the patient’s demands during overhead and cross-body activity. In low grade (type II-III) injuries, persistent horizontal instability may be responsible for chronic complaints. This can occur during physical activity, where there is shifting of the acromion relative to the clavicle (for example washing the contralateral shoulder). This would represent a reasonable explanation for unsatisfied outcomes in type-II and III AC joint dislocations where a horizontal component of instability has been misdiagnosed primarily (185). Some evidence shows a decrease in strength with a bench press, but no deficits with rotational activities when treating type-III AC joint injuries non-operatively (187). Operative management also leads to an improved cosmetic outcome, but at the trade-off for increased sick leave (183, 191). However, the majority of data for type-III, and especially type-II AC joint injuries does not show a clinical difference between operative and non-operative treatment. Chronic changes at the AC joint, such as osteolysis, distal clavicle hypertrophy, and calcification of the CC ligaments do not lead to a poor prognosis or painful shoulder (184, 192). Most patients have excellent outcomes with non-operative treatment, regain full ROM, and have a painless shoulder in type II and III injuries (184, 185, 191-194).There is a general consensus that high-grade injuries (types IV, V, and VI) should be treated operatively (183-187, 192). Although the published evidence is limited, these injuries cause significant pain, deformity, and long-term disability in shoulder function (186, 187, 195). | | | | | | | |
| **Time sensitivity** | High-grade injuries types IV–VI should be treated operatively within a time frame of 2–3 weeks after injury (185, 192, 196-199). | | | | | | | |
| **Cost effectiveness** | There is limited data on the cost-effectiveness of AC joint repair and/or reconstruction. To analyze this, a formal health economical assessment needs to be perfomed.2 | | | | | | | |
| **Risk for COVID-19 complications** | The typical patient who has an acute AC joint separation that undergoes repair or reconstruction is a young and healthy patient who has low risk for complications. In addition, surgery is performed with a short hospital stay or in an outpatient surgery center, further decreasing the risk. | | | | | | | |
| **Risk for surgical complications** | Given the wide variety of operative techniques, the postoperative complications are variable. However, complications requiring revision surgery are uncommon (184, 200, 201).Complications rates range from 23-52% and are most commonly associated with graft or hardware failure and loss of reduction (200, 201). | | | | | | | |
| **Post-surgical needs** | Moderate, home exercises can be performed in the first 6-8 weeks. Formal PT is recommended twice weekly from 8-16 weeks. Wound care is simple and can be monitored by the patient and via telehealth. | | | | | | | |
| **Social/home support** | Low, injuries typically occur in younger patients that are independent for ADL at home. They may require assistance for activities outside the house such as transportation to doctors’ appointments and PT. | | | | | | | |
| **Shoulder Instability** | | | | | | | | |
| **Incidence** | Shoulder dislocations occur at a 0.02%-1.7% annual rate in the general population, the prevalence is 2-8% in the general population. The highest percentage occurs in males from the age of 10-20 followed by the 50-60 year age group.(203-208) | | | | **Outpatient surgery is most common; however, an overnight observation or admission may be indicated if an open stabilization or arthroplasty is performed** | | | |
| **Number of surgeons/assistants:** 2 or 3 | **Anesthesia** At surgeon and anesthesiologist discretion   1. General + local anesthetic OR (need ventilator) 2. General + regional (interscalene block) 3. Sedation + regional (interscalene block) | | | **Surgical Time:** 54-128 minutes(214, 215) | | | **Average Cost:** $4,747-15,287, if a distal tibial allograft is used the cost may be 2.9 x higher compared to a Latarjet procedure.(209-213) | |
| **Short-term disability** | Associated with significant pain, swelling, deformity, loss of ROM and potential neurovascular deficits. Upon initial presentation reduction under sedation is recommended in the emergency department. If the dislocation is irreducible or locked, closed reduction should be attempted under general anesthesia with preparedness to perform an open reduction with or without concomitant procedures. Associated pathology with glenohumeral dislocations include labral tears, glenohumeral ligament avulsions, rotator cuff tears, greater tuberosity fractures, impaction injuries to the humeral head, glenoid fractures, neurologic and vascular injuries.(216-223) After a stable glenohumeral reduction is achieved additional interventions may be considered depending on patient age, recurrence risk and concomitant pathology. Although less common to present for acute care, a shoulder dislocation in the setting of multidirectional instability also warrants reduction. These patients have increased ligamentous laxity and/or capsular redundancy which predisposes the shoulder to subluxation and dislocation events. In this situation, physical therapy is prioritized and typically attempted for 6 months prior to operative intervention.(224, 225) | | | | | | | |
| **Long-term disability** | Recurrent dislocations are the main concern for long term disability. This causes repeated soft-tissue and boney injury which can further predispose the patient to instability events. Long term sequelae include repeat rotator cuff and capsuloligamentous damage, but irreversible changes such as glenoid bone loss and other articular defects potentiate.(216-223) Ultimately glenohumeral dislocation arthropathy may result with advanced arthritic disease.(218) | | | | | | | |
| **Time sensitivity** | A glenohumeral dislocation should be reduced as soon as possible. If the glenohumeral joint is irreducible under sedation, operative reduction by closed or open means should be performed within 24 hours. If imaging reveals a displaced glenoid fracture (especially if > 20% of the glenoid is involved) or a traumatic rotator cuff tear, a repair should be considered within 4-6 weeks of the injury. If there is a large humeral head defect that is recurrently engaging with the glenoid, surgery should also be expedited. If the window of opportunity to fix a large bony Bankart is lost, other procedures that can restore bone loss (Latarjet or distal tibial allograft) and have good surgical outcome can be performed (202, 228). Surgical intervention should also be considered for patients with a recurrence risk >70%.(226) However in the absence of significant boney injury, bone loss, or rotator cuff pathology, treatment can be delayed. There are trends towards an increase in recurrent instability in patients with multiple dislocation episodes after undergoing surgical repair, but they have not reached statistical significance.(289) Patients with a low recurrence risk or less severe structural damaged may be treated non-operatively with physical therapy after glenohumeral reduction is achieved. (216-223) | | | | | | | |
| **Cost effectiveness** | Both arthroscopic repair and Latarjet are cost-effective compared to non-operative treatment with an incremental cost-effectiveness ratio of $3,082-4,214 and $1,141-4681, respectively.(214, 227) | | | | | | | |
| **Risk for COVID-19 complications** | The typical patient who has an acute shoulder dislocation that undergoes operative intervention is a young and healthy patient who has low risk for complications. Most stabilization procedures can be performed with a short hospital stay or in an outpatient surgery center, further decreasing the risk. In older individuals or in patients that may require arthroplasty, the risk increases due to potential overnight observation or admission. | | | | | | | |
| **Risk for surgical complications** | Given the wide variety of operative techniques, the postoperative complications are variable. However, the most common complication is recurrent instability which occurs at a rate of 6-35 %.(219, 227) Less than half of these patients require a revision surgery. Open stabilization procedures typically have a lower recurrent dislocation risk but a higher rate of nerve injury.(219) | | | | | | | |
| **Post-surgical needs** | Moderate, home exercises can be performed in the first 6 weeks. Formal physical therapy is recommended twice weekly from 6-12 weeks. Wound care is simple and can be monitored by the patient and via telehealth. | | | | | | | |
| **Social/home support** | Low for injuries that occur in younger patients that are independent for daily activities at home. They may require assistance for activities outside the house such as transportation to doctors’ appointments and physical therapy. Moderate support for older patients, and patients who may require arthroplasty, however most activities of daily living will still be achievable. | | | | | | | |
| **Distal biceps avulsion** | | | | | | | | |
| **Incidence** | 2.5 per 100,000 patients-years. The average age is 47 years old; over 90% are males(229). | | | | | | | |
| **Number of surgeons/assistants:** 2 or 3 | **Anesthesia:** At surgeon and anesthesiologist discretion   * 1. Regional block + sedation   2. Regional block + general anesthesia   3. General anesthesia only | **Surgical Time:** Average of 79 to 91min(232, 233). | | | **Average Cost:** highly dependent on operative time, facility in which surgery is done (ambulatory surgery center versus hospitals), and implants used for fixation(230, 231). | | | **Outpatient surgery** |
| **Short-term disability** | Severe elbow pain, ecchymoses, and Popeye deformity are usually observed after distal biceps tendon tears. Surgery is indicated to control pain and restore flexion and supination strength(234-236). | | | | | | | |
| **Long-term disability** | Typically, operative treatment is recommended for the majority of patients, especially young and active individuals(236, 237). A few case series or non-randomized comparative studies analyzed outcomes of operative versus non-operative treatment for distal biceps tendon tears(238-242). In general, surgical repair outperforms non-operative management for supination, elbow flexion, and grip strength, as well as patient reported outcomes. For the cohorts treated non-surgically, loss of supination strength ranges from 27% to 40%, and loss of flexion ranges from 7% to 31%. About 40% of non-operated patients in one cohort reported subjective weakness for activities that requires elbow flexion and supination, while 5% of the patients required assistance of the contralateral arm due to disability(238). ﻿Moreover, loss of supination associated with loss of flexion strength and endurance generally requires the patient to adapt by increasing the use of the shoulder muscles, with abduction of the shoulder and the arm while externally rotating the forearm to increase supination power(238, 239). | | | | | | | |
| **Time sensitivity** | Repairs of tears with timing from injury longer than 4 to 6 weeks are frequently more challenging as they can be complicated by adhesions and tendon shortening(236). For late repairs, advanced imaging ideally can be used in the preoperative planning to assess tendon retraction and evaluate the need for graft supplementation(237). However, most patients with chronic tears, even associated with tendon retraction, do not require graft augmentation. In a retrospective case-control study in which one group consisted of distal biceps repairs that required elbow flexion higher than 60˚for graft fixation, only one among 19 chronic tears (with an average time from injury to surgery of 21 weeks) needed allograft augmentation(243). Another retrospective study compared chronic tears treated with primary repairs versus chronic tears that required graft augmentation for reconstruction. Delayed reconstruction yielded similar strength, ROM, and complication rates, but worse functional outcome scores compared with primarily delayed repair(234). | | | | | | | |
| **Cost effectiveness** | To our knowledge, no study analyzed the cost-effectiveness of distal biceps repairs. It is reported that cost is significantly higher when a reconstruction with allograft or autograft is necessary(233, 244). | | | | | | | |
| **Risk for COVID-19 complications** | Considering that the average age for patients undergoing distal tendon repairs is 47 years old, this population presents a moderate risk for hospitalization if they develop COVID-19. Moreover, a short hospital stay minimizes this risk. | | | | | | | |
| **Risk for surgical complications** | The overall complication rate is about 25%, most of them being minor complications. The most common complication cutaneous nerve neuropraxia, posterior interosseous nerve palsy, proximal radioulnar synostosis, and wound complications. Reoperation rates is about 4.5%(232, 245, 246). | | | | | | | |
| **Post-surgical needs** | Low. After a short immobilization period with a splint or an elbow brace, PT may be needed. Wound care can be monitored by the patient and on telehealth visits. | | | | | | | |
| **Social/home support** | Since the vast majority of postoperative protocols entail a short period of immobilization followed by progressive gaining in the ROM, patients might need some form of assistance at home for performing ADL. | | | | | | | |

ROM: range of motion; OA: osteoarthritis; ADL: activities of daily living; TKA: total knee arthroplasty; ACL: anterior cruciate ligament; MRI: magnetic resonance imaging; OR: operating room; PT: physical therapy; UK: United Kingdom; TTTG: tibial tuberosity-trochlear groove; TTO: tibial tuberosity osteotomy; OCD: osteochondritis dissecans; PROs: patient reported outcomes; CPM: continuous passive motion; KD: Kennedy; KL: Kellgren and Lawrence; AC: acromioclavicular