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Are Hamstring Tendons Like Lizard Tails?

ABSTRACT & COMMENTARY

Synopsis: *Sequential MRI scans at various time periods following hamstring tendon harvest revealed progressive regrowth of the tendons toward their tibial attachment.*

Source: Rispoli DM, et al. Magnetic resonance imaging at different time periods following hamstring harvest for anterior cruciate ligament reconstruction. *Arthroscopy.* 2001;17(1):2-8.

Much has been written regarding how the patellar tendon defect regenerates and can potentially be used as another graft source for ACL reconstruction. However, few people are willing to actually use this potentially weakened tissue. Only a few scattered case reports have suggested hamstring tendons may also regenerate after they are harvested for ACL reconstruction. In this study, 45 patients had the semitendinosus and gracilis tendons harvested in standard fashion for quadruple hamstring ACL reconstruction by Rispoli and colleagues over a 20-month period. Of these, 21 volunteered to have MRI scans at time points ranging from 2 weeks to 32 months following tendon harvest. MRIs were performed with a 1.5 tesla magnet and prospectively evaluated by 2 musculoskeletal radiologists who were blinded to the time interval between graft harvest and MRI.

The results showed a progressive regrowth of the tendons toward the tibial attachment. Only fluid was evident at the early time points, but by 6 weeks there were disconcernable tendons at the level of the superior pole of the patella. Tendon regrowth progressed from the level of the joint line at 3 months, to within 1-3 cm of the tibial attachment by 12 months, to within 1 cm of the tibial attachment at 32 months. Although the regenerate tissue was a bit ill-defined and variable in the first 6 weeks, by 3 months the tendons appeared to have normal signal characteristics as compared to native tendon. Semitendinosus appeared to regenerate more predictably than the gracilis.

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INSIDE

COMMENT BY DAVID R. DIDUCH, MS, MD

Hamstring ACL reconstruction is becoming increasingly popular as fixation methods improve. There is limited donor-site morbidity, and the tendon has been shown to be stronger than the patella tendon biomechanically. A major advantage also is the lack of detrimental effect on the extensor mechanism and quadricep strength. Often after patellar tendon harvest, quadricep strength takes 6-12 months to return to normal. Interestingly, patients who have their hamstring tendons harvested rapidly regain hamstring strength. This led Rispoli et al to postulate that the tendons regrow and actually function. Their study effectively demonstrates by MRI criteria that the tendons do regrow analogous to a lizard tail. The mechanism of this is unknown but intriguing. The study did not attempt to assess if the new tendons were functional, however. Cross-sectional area of the muscles showed no significant atrophy of the sartorius or semitendinosus muscle. The gracilis seemed to regenerate a little less predictably and did demonstrate some degree of atrophy.

The normal hamstring tendons lie invested in a fascial plane along the medial aspect of the knee. This tissue plane may help explain the regeneration of the harvested tendon. It appears to initiate proximally in a more vascular area and proceed distally along the fascial plane toward the tibial attachment. Although these somewhat random time points for MRI evaluation of different patients are not as valuable as prospective, sequential MRIs on the same patient, this certainly appears to demonstrate that the lizard tail phenomenon exists. A major unanswered question is whether this tendon achieves a functional tibial attachment and whether it can be harvested again as a graft source. Isokinetic testing suggests that the tendons are functional, as strength has been shown by many investigators to return to normal within a few months.

This is a major finding with implications for surgeons, therapists, trainers, and patients. It is likely to shape the way we perform ACL reconstructions in the future as more is learned. I understand that some of the investigators are now proceeding to an animal model to better understand the physiology of this lizard tail phenomenon. ❖

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Biodegradable Implants for Meniscal Repair

ABSTRACT & COMMENTARY

Synopsis: *From the American Journal of Sports Medicine comes a report of 5 patients with complications from biodegradable "all-inside" meniscal repair systems including cyst formation, knee joint effusions, and femoral condylar injury.*

Source: Tingstad EM, et al. Complications associated with the use of meniscal arrows. *Am J Sports Med.* 2001;29(1): 96-98.

Tingstad and colleagues describe 5 patients with complications from the use of a biodegradable (poly-L-lactic acid) meniscal repair device (Bionx—Blue Bell, Pa). Complications included 4 patients with recurrent cyst formation, including 1 patient with palpable objects noted subcutaneously along the medial joint line. All cysts resolved with aspiration and time. A fifth patient underwent an incidental arthroscopy 6 months post-repair and was noted to have femoral furrowing related to the heads of the meniscal arrows. Tingstad and colleagues note that the meniscal arrows were placed according to manufacturing guidelines (arrow length selection and impaction

of the arrow), concluding that there may be a significant design problem. Tingstad et al were encouraged by the fact that the cyst formation appeared self-limiting. Clinically, the meniscal tears healed with the all-inside biodegradable devices.

COMMENT BY ROBERT C. SCHENCK, Jr., MD

Meniscal repair has been an evolving technical process, from open, to arthroscopically assisted (inside-out, outside-in), to an all-arthroscopic "all-inside" technique. Several devices have been developed to repair a meniscus with such a technique in an attempt to avoid a posterior incision or portal. The most recent advancements have included various biodegradable arrows or tacks, which offer ease of insertion avoiding the need for intra-articular knot tying. Recently, in the October 2000 issue of *Arthroscopy*, 2 separate reports documented the incidence of chondral injury (reported by Tingstad et al, patient No. 5, above) due to the same meniscal arrow device with grooving of the articulating femoral condyle.[1,2]

To preface this discussion, I have no financial involvement with any of the meniscal repair device manufacturers. The true crux of the problem, in my opinion, lies not in the device shape or design, but in the biomaterial selection. PLLA is selected because of its stiffness and ability to produce a device that can indeed fix and hold the meniscal tear during the healing phase. In the case reports, the meniscus repair did indeed produce meniscal healing. Unfortunately, the time line of absorption has been reported to be more than 3 years for poly-L-lactic acid, and the long-term presence of the implant may be the underlying cause for joint surface injury. In a recent report by Martinek et al,[3] a poly-L-lactic acid interference screw was removed 2.5 years after insertion, documenting the slow resorption of such a biodegradable material. Slow resorption time could be the Achilles heel when using such a material in which articular motion could result in hyaline cartilage contact and injury. Proper placement of any device is critical, and even the most ideal biomaterial improperly placed could scuff the knee joint. Ideally, and in my opinion, the device should resorb more quickly over a 2-4 month period to avoid such articular lesions, independent of the design. Use of other materials for meniscal repair with faster resorption times (ie, polydioxanone, PDS, Mitek Fastener System, Ethicon, Westwood, Mass: 5-week resorption time) may decrease the risk of chondral injury but may also affect mechanical properties and healing rates. Until more clinical studies are available that assess healing rates plus the incidence of complications, we really don't know how long these devices need to stay around to do the job. Because these are case reports rather than clinical series, we also do not know the true incidence of such complications with these devices. ❖

References

1. Anderson K, et al. Chondral injury following meniscal repair with a biodegradable implant. *Arthroscopy.* 2000;16(7):749-753.
2. Ross G, et al. Chondral injury after meniscal repair with bioabsorbable arrows. *Arthroscopy.* 2000;16(7): 754-756.
3. Martinek V, et al. The fate of the poly-L-lactic acid interference screw after anterior cruciate ligament reconstruction. *Arthroscopy.* 2001;17(1):73-76.

Heat Kills

ABSTRACT & COMMENTARY

Synopsis: *Bipolar radiofrequency energy was shown to create a large zone of chondrocyte death within articular cartilage that was not evident on light microscopy.*

Source: Lu Y, et al. Effect of bipolar radiofrequency energy on human articular cartilage: Comparison of confocal laser microscopy and light microscopy. *Arthroscopy.* 2001;17(2): 117-123.

Radiofrequency probes, both monopolar and bipolar, have rapidly gained acceptance among orthopaedic surgeons. Although initially developed for soft tissue shrinkage applications, they have been advocated for treatment of fibrillated articular cartilage despite the absence of objective clinical studies that document an advantage over conventional debridement with a shaver. More importantly, studies evaluating their effect on chondrocytes are few, and initial studies used only light microscopy to assess chondrocyte viability.[1,2]

Lu and colleagues have now published their third study that demonstrates chondrocyte death with radiofrequency energy. Using fresh, human, osteochondral specimens obtained during knee replacement surgery, Lu et al waved the bipolar radiofrequency probe (ArthroCare) over a 3-second interval just above the chondral surface in an arthroscopic environment. Specimens were then analyzed using a fluorescent vital cell staining technique that is sensitive and accurate for chondrocyte viability. Confocal laser microscopy detects live cells as green and dead

cells as red. This was compared to conventional light microscopy.

They found that radiofrequency killed a large zone of chondrocytes proportionate to the temperature setting and sometimes all the way to subchondral bone. All settings killed chondrocytes to a much greater degree than would be seen with mechanical shaving. Light microscopy could not detect chondrocyte death, as the cells visually appeared normal at the time of treatment. They concluded that light microscopy gives a false impression of cell viability and that radiofrequency kills an alarmingly high number of chondrocytes surrounding the treated area.

COMMENT BY DAVID R. DIDUCH, MS, MD

Heat kills. Make no mistake. Lu et al are to be congratulated for giving us objective data that demonstrate that these new radiofrequency probes are not to be used on articular cartilage. Anyone doubting this should look at the impressive figures in this paper showing a large zone of red-cell death that looks like an expanding mushroom cloud. Although energy settings correlated with the size of the zone of death, it was unacceptably large in all cases. Interestingly, one of the companies manufacturing competing devices funded this study (Oratec), indirectly making the data all the more believable. We need to understand that this technology delivers heat upward of 100-160°C to the surface while chondrocytes die at about 50°C.

I must admit that I jumped on board with this technology when it first became available. Visually, the surface is smoothed in an attractive way. However, as Lu et al demonstrate well, there is more to this than meets the eye (or the microscope). Those chondrocytes beneath the surface are dead, yet trapped within the matrix. Over time, the matrix will deteriorate, as cells do not support it. I have seen this on second look arthroscopy with dramatic loss of articular cartilage evident at about 1 year or so. Needless to say, I no longer use radiofrequency on the joint surface. I think the message in this paper needs to get out to surgeons. Radiofrequency has its place, just not on the joint surface. ❖

References

1. Kaplan L, et al. The acute effects of radiofrequency energy in articular cartilage: An in vitro study. *Arthroscopy.* 2000;16:2-5.
2. Turner AS, et al. Radiofrequency (electrosurgical) ablation of articular cartilage: A study in sheep. *Arthroscopy.* 1998;14:585-591.

Should OATS Be Proud?

ABSTRACT & COMMENTARY

Synopsis: *Two osteochondral autograft techniques were compared—1 leaving the plugs 2-mm proud and the other flush with the surrounding cartilage. The specimens were studied 3 months postoperatively, and the grafts placed proud were associated with complications.*

Source: Pearce SG, et al. An investigation of 2 techniques for optimizing joint surface congruency using multiple cylindrical osteochondral autografts. *Arthroscopy.* 2001;17(1):50-55.

Osteochondral autografting, commonly referred to as "OATS" (so named for one of three commercially available systems [Osteochondral Autograft Transfer System, Arthrex, Inc—Naples, Fla]) is becoming a popular method for treating isolated focal chondral injuries in the knee. Although original animal studies demonstrated that these grafts can successfully incorporate, there have not been any studies comparing different techniques for plug insertion.[1,2] Some anecdotal reports have suggested that these grafts should be placed proud, which would theoretically allow them to "seat" with knee range of motion and weight bearing. This study was designed to study that issue.

Full-thickness chondral defects were created on the weight-bearing surface of the medial femoral condyle (the most common clinical location for chondral defects) in 13 adult sheep. Three 4.5 × 10 mm plugs were inserted in a triangular pattern into 14 mm deep recipient sites. The MosaicPlasty technique and instrumentation (Acufex, Smith & Nephew Endoscopy—Mansfield, Mass) was used in this study. In 6 animals, the plugs were placed 2-mm proud, and in the remaining 7 animals, the plugs were placed flush with the surrounding articular surface. The animals were evaluated 3 months postoperatively, and the condyles were evaluated grossly, radiographically, and histologically. The proud grafts did reposition with weight bearing but were associated with fissuring and subchondral cavitation. Pearce and colleagues concluded that grafts should be delivered flush with the joint surface to avoid these complications.

COMMENT BY MARK D. MILLER, MD

Although this animal study provides some important insight into proper technique for osteochondral "plug" transfers, 2 important variables were introduced in this study that may differ from clinical appli-

cation. First, the plugs were inserted into recipient sites that were 4 mm deeper than the plugs themselves. Therefore, the plugs were required to rely on sidewall friction alone for stabilization. Second, the animals were allowed to weight-bear immediately postoperatively. Most protocols for this procedure allow an initial period of protected weight-bearing. Additional studies may provide further insight into these issues. For now, however, Pearce et al's recommendations that the plugs be inserted flush with the adjacent articular surface (as the manufacturers recommend) should be followed. It is also critical, in my opinion, to both harvest and deliver these plugs with a precise technique. Plug harvest and delivery requires perpendicular orientation of the instruments that may not be possible with arthroscopic techniques alone. Arthrotomies (or at least mini-arthrotomies) should be used whenever this principle is at risk for compromise. ❖

References

1. Hangody L, et al. Autogenous osteochondral graft technique for replacing knee cartilage defects in dogs. *Orthop Int.* 1997;5(3):175-181.
2. Hangody L, et al. Osteochondral plugs: Autogenous osteochondral mosaicplasty for the treatment of focal chondral and osteochondral defects. *Op Tech Orthop.* 1997;7(4):312-322.

Knee Effusion and Neural Inhibition

ABSTRACT & COMMENTARY

Synopsis: *Knee joint effusion has an inhibitory effect on the vastus medialis and a facilitatory effect on the soleus.*

Source: Hopkins JT, et al. Effect of knee joint effusion on quadriceps and soleus motoneuron pool excitability. *Med Sci Sports Exerc.* 2001;33(1):123-126.

The effusion associated with knee joint injury results in muscle weakness, atrophy, and deficits in neuromuscular control. This study sought to create an experimental model in which the effect of knee effusion on motoneuron pool recruitment could be measured. For this purpose, the quadriceps and soleus Hoffman reflexes (H-reflex) were measured before and after the inducement of an artificial knee effusion.

The H-reflex was elicited by applying a percutaneous stimulus to the femoral nerve in the femoral triangle for the quadriceps and the tibial nerve in the popliteal fossa for the soleus. Surface electromyography over the belly of the medial soleus and vastus medialis (superomedial to the patella) measured the response to the percutaneous stimulation. Seven to 12 stimuli were delivered at 20-second intervals at varying intensities to find the maximum H-reflex. The H-reflex measurements were obtained before inducement of the effusion and at 30- 90- 150- and 210-minute intervals following the effusion.

For the knee effusion procedure, 2 mL of lidocaine was first injected for anesthetic purposes. Next, 30 mL of sterile saline was injected into the superolateral knee joint capsule. Effusion wave and ballotable patella tests confirmed the presence of an effusion within the knee joint.

Two, one-way repeated measures analysis of variance found that the soleus H-reflex increased and the quadriceps H-reflex decreased after the effusion. All posteffusion soleus and quadriceps measures were significantly higher and lower, respectively, in comparison to the pre-effusion measures.

COMMENT BY DAVID H. PERRIN, PhD, ATC

Most clinicians surmise that inhibition of the quadriceps causes strength loss, atrophy, and deficits in neuromuscular control, and that knee joint effusion is a likely precursor to this process. This and several other studies have demonstrated a quadriceps inhibition following effusion. This study further found that the inhibition lasts for at least 120 minutes following inducement of the artificial effusion.

Perhaps the most interesting findings were the increased activity in the soleus motoneuron pool, and the moderate inverse relationship between the soleus and vastus medialis H-reflexes after inducement of the knee effusion. Hopkins and colleagues postulated that facilitation of the soleus could be a compensatory mechanism in response to the inhibited quadriceps.

As with all research, this study's design has some strengths and weaknesses. A strength is that the effects of effusion on neural inhibition could be measured in the absence of associated pain. The amount of the effusion could also be quantified. The weaknesses are that the composition of the effusion was saline and only the acute effect of an effusion was measured. In the injury model, swelling may consist of synovial fluid and blood, and the chronic effects of an effusion may have greater relevance to neuromuscular function in rehabilitation. ❖

Full-Thickness Rotator Cuff Tears: Rehabilitation vs. Surgery

ABSTRACT & COMMENTARY

Synopsis: *A retrospective, nonrandomized study of full-thickness rotator cuff tears was undertaken to evaluate the efficacy of nonoperative management. Modest improvements in shoulder function and comfort were noted when treating patients without surgery; furthermore, the overall responsiveness of shoulder function to nonoperative intervention was poor.*

Source: Goldberg BA, et al. Outcome of nonoperative management of full-thickness rotator cuff tears. *Clin Orthop.* 2001;382:99-107.

This study documents the functional outcome associated with nonoperative treatment of full-thickness rotator cuff tears treated by the shoulder service at the University of Washington. This study used contemporary measures of shoulder function (The Simple Shoulder Test) and health status (SF-36), giving Goldberg and colleagues the opportunity to evaluate both function and health in a modern outcome study. Forty-six patients were selected consecutively based on the following inclusion criteria: 1) full-thickness cuff tear diagnosed on a secondary radiographic study (MR, arthrogram, or ultrasound); 2) absence of a Worker's Compensation claim; 3) minimum 1-year follow-up; and 4) election of nonoperative management by the patient. Treatment involved stretching and strengthening exercises for the remaining intact rotator cuff muscles. At an average follow-up of 2.5 years, 59% of patients experienced improvement, 30% noted worsening, and 11% remained unchanged. The ability to sleep on the affected side and the ability to place the hand behind the head were significantly improved by nonoperative management. Patients who improved were more likely to have a rotator cuff tear of the dominant extremity, had a lower average initial shoulder function score (on the Simple Shoulder Test), and had more difficulty tucking their shirt behind their back. Interestingly, several general health parameters significantly worsened during the follow-up, suggesting that the patients were of declining health.

COMMENT BY ROBERT C. SCHENCK, Jr., MD

Controversy exists over clinical decision-making in the management of full-thickness rotator cuff tears. Goldberg et al note only "modest improvement in shoulder function and comfort when patients were treated without surgery; the overall responsiveness of shoulder function to nonoperative intervention was poor." In addition to the nonuniform documentation of the cuff tear, the study is retrospective and nonrandomized whereby patients elected nonoperative care. Although a randomized, prospective design is ideal, in the present study, one would expect a bias for the best possible results with nonoperative treatment as the patients chose this type of management. In contrast, the improvement with rehabilitation was modest. In my opinion, it is unclear whether the results would have been better than a control population. The finding of declining health status is interesting and may indicate some concern by the patients of the safety of undergoing a general anesthetic, in effect prompting the selection of nonoperative care.

I found useful the identifying features of the patient who was more likely to improve with rehabilitation: those with difficulty tucking in their shirts, dominant extremity involvement, and those with poorer initial functional scores. Goldberg et al note that difficulty with tucking in one's shirt is related to internal rotation deficits or posterior capsular tightness and may be a separate phenomena from a cuff tear, thus making the patient more responsive to a rehabilitation program using stretching techniques. Relating this study to my clinical experience underlines the following points: those patients with initial stiffness and poorer function are more commonly improved with nonoperative management. A randomized trial is still needed to address the comparison of operative and nonoperative treatment options, and exercises vs. no treatment at all. ❖

Alcohol and College Athletes

ABSTRACT & COMMENTARY

Synopsis: *Athletes are at high risk for binge drinking and the consequences that follow.*

Source: Nelson T, Wechsler H. Alcohol and the athlete. *Med Sci Sports Exerc.* 2001;33(1):43-47.

The purpose of this article was to study the harms and incidence of "binge" drinking in the college athlete. The participants in the study were students younger than 24 years of age who responded to a questionnaire sent to a representative sample of 4-year colleges. The response rate for the questionnaire was 60%. A total of 12,777 students of which 2172 were

athletes responded to the questionnaire. Athletes were defined as those participating in physical activity for more than 1 hour per day. A drink was defined as imbibing 12 oz of beer, 4 oz of wine, or 1 shot of whiskey. Binge drinking was defined as drinking 5 or more drinks in a row for men or 4 for women. This measure of binge drinking was previously determined to be a strong predictor of adverse social consequences for alcohol consumption.

The results showed that athletes reported significantly more binge drinking, heavier alcohol use, and a greater number of alcohol-related incidents, including driving while drunk and driving with someone else who was drunk. Athletes reported a greater number of social and parental issues related to their drinking. They reported drinking because they were uncomfortable with the opposite gender and to fit in with friends. Individual athletes reported that 70% of their friends were binge drinkers. Athletes also reported that they received greater exposure to educational efforts discouraging alcohol use than nonathletes did.

COMMENT BY JAMES R. SLAUTERBECK, MD

"*And the survey sez*". . . Athletes are at high risk for the ill effects of binge drinking.

The educational efforts by the National Collegiate Athletic Association (NCAA), individuals, universities and team physicians need to aggressively reach out to athletes. Although our high-profile student-athletes perform at top levels and are placed upon pedestals by fans, their behaviors show insecurities as they drink to fit in with friends and to feel comfortable with the opposite sex more than the typical college student. Personal insecurity affects even these high-performance achievers.

Errors in judgment are common while under the influence of alcohol and may place the lives of the athlete or teammates in significant danger. Serious alcohol related injury to athletes could have significant effect on the athlete, team, and school. The most alarming information gleaned from this study is the fact that an athlete who is a binge drinker will drive drunk or drive with someone who is drunk more often than the typical college student. Certainly, as physicians we are not responsible for alcohol-related injuries, but it is sad to witness a starting varsity athlete survive the season and end up in a wheelchair paralyzed due to an alcohol-related motor vehicle wreck.

As team physicians, we should keep our attention focused on the total care of our athletes. Alcohol misuse should be viewed as a significant problem. Maybe during the preseason assessment of the athletes or in our history and physicals before surgery, a more thorough assessment of the athlete's alcohol consumption should be performed. Proactive prevention measures should be considered. It is reasonable to assume that these young athletes are seeking good role models, and physicians are in the position to provide the example and proactive intervention.

The risks to self, team, families, and friends are too great to ignore. Although this study suffers from only 60% survey return, it still is sobering to think our disciplined athletes succumb to peer and other social pressures and place themselves and others at risk for serious injury. We must continue to work with the NCAA and our respective colleges and universities to educate our athletes about the harmful effects of alcohol use on athletic performance and life. We should consider setting up a multidisciplinary approach to the treatment and prevention of alcohol-related issues. ❖

CME Questions

19. Successful nonoperative management of patients with full-thickness rotator cuff tears is best seen with:

a. those with worsening health status.
b. those with better initial functional scores.
c. those with difficulty tucking in their shirts.
d. those with workman's compensation insurance.
e. those with an affected nondominant extremity.

20. Athletes:

a. are at high risk for binge drinking.
b. are at low risk for binge drinking.
c. binge drink less commonly than college students who are not in athletics to fit into the crowd.
d. binge drink less commonly than college students who are not in athletics because of social pressures.

21. Osteochondral autografts (OATS or MosaicPlasty plugs) used in the treatment of focal articular cartilage defects should be inserted:

a. approximately 2 mm below the level of the surrounding articular cartilage.
b. flush with the surrounding articular cartilage.
c. approximately 2-mm proud in relation to the surrounding articular cartilage.
d. approximately 4-mm proud in relation to the surrounding articular cartilage.

22. Which of the following correctly describes the effect of a 30 mL knee effusion on motoneuron pool excitability?

a. Quadriceps H-reflex is increased.
b. Soleus H-reflex is decreased.
c. Quadriceps H-reflex is decreased and soleus H-reflex is increased.
d. A direct correlation exists between the soleus and vastus medialis H-reflexes.

23. Following harvest of the hamstring tendons for ACL reconstruction, the harvested tendons:

a. do not regenerate.
b. regenerate from distal to proximal.
c. regenerate from proximal to distal.
d. scar down proximally to the unharvested semimembranosus.

24. Which of the recent complications associated with all inside biodegradable meniscal repair devices is the most worrisome?

a. Femoral condylar scuffing
b. Cyst formation
c. Subcutaneous fragments
d. Infection
e. Inflammatory response

25. Bipolar radiofrequency energy on articular cartilage was found:

a. to kill a large zone of chondrocytes beneath the surface.
b. to smooth the surface with little damage beneath.
c. to not affect the surface.
d. to shrink the surface.

Readers are Invited. . .

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