INTRODUCTION

There has been a recent increase in interest and awareness of non-arthritic hip injuries in tennis players. At the WTA physical examination for players in 2012, 18% of the 125 professional women tennis players examined noted a history of hip or groin pain (unpublished data). When reported in the literature, anywhere between 8 and 27% of injuries are to the pelvis/hip/groin in high level tennis players. Tennis is a sport where the hip is taken through its extremes of motion, subjecting the joint and its associated soft tissue structures to high and potentially injurious forces. As the muscles around the hip are important for the transfer of forces from the feet to the racquet as part of the kinetic chain, the hip is subjected to flexion (lunging for a low ball), extension (serve in the late cocking phase) and rotation in the serve motion and especially with the popular open stance mechanics. The sudden stops and starts and change in direction also put great forces on the hip.

The differential diagnosis of hip pain is quite broad in the tennis player. Hip pain can be caused by intra-articular or surrounding extra-articular pathology or be referred to the hip from a variety of sources. Some of the most common sources of pain in tennis players include labral tears, usually as the result of femoroacetabular impingement (FAI), hip flexor (including iliopsoas) strain, peri-trochanteric pain (trochanteric bursitis and gluteus medius syndrome), adductor strain and athletic pubalgia (commonly called the ‘sports hernia’) (Table 1).

Making a correct diagnosis is imperative to allow for the appropriate management of hip injuries with as rapid a return to play as possible. A careful history, physical examination and standard radiographs may provide important clues, with advanced imaging – such as magnetic resonance imaging (MRI) arthrography – helping confirm the diagnosis. Arthroscopy has also been advocated as a diagnostic tool for intra-articular hip pathology, although this is rarely necessary.

CLINICAL EVALUATION

Pertinent history

The first step in evaluating the tennis player’s hip is to obtain a thorough history. Important questions to ask the tennis player with hip pain should focus around:

- the presence or absence of trauma (including mechanism of injury),
- the location of the pain,
- onset (acute, with one shot, after a practice, gradual),
- was there a recent change in mechanics,
was there a recent change in duration of training,
was there a recent change to the surface played on,
duration and severity of symptoms,
timing relative to the tennis play (immediately or late in the match, improve when warmed up, do they have to stop play) and
is there a particular shot or motion that makes it worse.

Exacerbating and alleviating factors along with specific activities in tennis that are limited as well as the effect on activities of daily living should be identified. The examiner should inquire about prior hip injuries and/or surgeries and prior treatments. Level of play, mechanics (one vs two-handed backhand, open stance), amount of play and intensity can be helpful in determining aetiology as well as the goals of the patient. It is important to discern a history of ligamentous laxity or treatment for acetabular dysplasia as an infant. A history of hip pain as an adolescent that may be a clue to previous hip problems such as slipped capital femoral epiphysis and Legg-Calve-Perthes can also be helpful.

A thorough history will help delineate intra-articular vs extra-articular sources of pain. Patients with symptomatic intra-articular problems, such as chondral flaps and labral tears, will often complain of pain and mechanical symptoms. Typically, the pain is deep and localised in the anterior groin or inguinal region, although this pain may be referred to the medial thigh, the region proximal to the greater trochanter laterally or in the buttocks. Frequently, patients will grab their hip with the thumb in the inguinal region and the long finger posterolaterally, stating the pain is at the crossing between their thumb and fingers, placed at the groin and posterolateral hip.

**Table 1**

<table>
<thead>
<tr>
<th>Intra-articular</th>
<th>Peri-articular</th>
<th>Referred</th>
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<tbody>
<tr>
<td>• Labral tears</td>
<td>• Adductor strain</td>
<td>• Lumbar Spine</td>
</tr>
<tr>
<td>• Chondral damage</td>
<td>• Hip flexor strain &amp; tendinopathy</td>
<td>• Pars injuries</td>
</tr>
<tr>
<td>• Ligamentum teres tears</td>
<td>• Greater trochanteric bursitis</td>
<td>• Facet arthropathy</td>
</tr>
<tr>
<td>• Loose bodies</td>
<td>• Gluteus medius strain, tendinopathy and tears</td>
<td>• Disc degeneration</td>
</tr>
<tr>
<td>• Femoracetabular impingement</td>
<td>• External snapping hip syndrome</td>
<td>• Disc herniation as a lumbar spine differential</td>
</tr>
<tr>
<td>• Hip dysplasia</td>
<td>• Internal snapping hip syndrome</td>
<td>• Abdomen - Gastrointestinal</td>
</tr>
<tr>
<td>• Hip instability</td>
<td></td>
<td>• Pelvis - Genitourinary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Abdominal muscle strains</td>
</tr>
<tr>
<td>• Hamstring strain &amp; tendinopathy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Piriformis syndrome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Athletic pubalgia/sports hernia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Osteitis pubis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Other hernias (inguinal and others)</td>
<td></td>
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</tbody>
</table>

Figure 1: Depicting the ‘C-sign’. A characteristic sign patients with intra-articular hip pain will often demonstrate. They note the pain is at the crossing between their thumb and fingers, placed at the groin and posterolateral hip.

Table 1: Common sources of hip pain in tennis players.
popping or locking within the joint with ambulation or other hip motion, although this is less specific for intra-articular sources of symptoms.

Patients with extra-articular sources or referred pain will have varying complaints. Pain located in the thigh or buttocks, or pain that radiates distally below the knee, is likely to originate from the lumbar spine or buttock and proximal thigh musculature. Pain located in the lower abdomen and/or at the adductor tubercle – particularly with sit ups and other exertional activities – can indicate athletic pubalgia or osteitis pubis. Pain located around the greater trochanter may be trochanteric bursitis or gluteus medius syndrome and when associated with snapping can be external snapping hip syndrome. Internal snapping hip is usually audible and felt deep inside or in the groin. The author identified painless internal snapping in more than half of 125 female professional tennis players evaluated on routine physical examination in 2012. Identification of associated symptoms such as weakness or numbness, back pain and exacerbation with coughing or sneezing, may indicate thoracolumbar pathology. Furthermore, one must remember that hip problems may present as pain in the knee, either as referred pain or patellofemoral pain from quadriceps atrophy in long standing hip pain favouring the extremity.

The social history may be important, especially in assessing risk for avascular necrosis.

The above information should provide the clinician with enough information to develop a preliminary differential diagnosis. This differential diagnosis will allow the clinician to pay special attention to specific areas of the complete hip examination.

**Physical examination**

The key to the physical examination is to determine if the pain originates from intra-articular or extra-articular pathology and to confirm the pain is not referred from a remote source, such as the spine, genitourinary system or lower abdomen. The majority of intra-articular pathologies can be aggravated by passive motion of the hip joint such as log-rolling and placement of the hip in the impingement position (flexion, adduction and internal rotation). Extra-articular conditions, on the other hand, will more typically be aggravated by localised palpation or resisted muscular contraction.

The hip may be more difficult to examine due to its deep structure, thick soft tissue envelope and constraint by its bony configuration. It is important to perform a consistent, comprehensive physical examination to best identify the underlying condition, starting with standing tests followed by seated, supine, lateral and ending with prone tests (Table 2).

**Table 2**

<table>
<thead>
<tr>
<th>Standing</th>
<th>Sitting</th>
<th>Supine</th>
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<tbody>
<tr>
<td>Gait</td>
<td>Iliopsoas strength</td>
<td>Flexion</td>
</tr>
<tr>
<td>Trendelenberg</td>
<td>Neurovascular examination</td>
<td>Internal &amp; external rotation</td>
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<tr>
<td>Leg length assessment</td>
<td>Labral stress/scour</td>
<td>FADIR/Impingement test</td>
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<tr>
<td></td>
<td>Thomas Test</td>
<td>Log roll</td>
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<tr>
<td></td>
<td>Hyperextension – external rotation</td>
<td>Hesselbach's test</td>
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<td></td>
<td>Adductor strength</td>
<td></td>
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<tr>
<td></td>
<td>Quadriceps atrophy</td>
<td></td>
</tr>
<tr>
<td>Lateral Decubitus</td>
<td>Palpate</td>
<td></td>
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<tr>
<td></td>
<td>Trochanteric bursa</td>
<td></td>
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<tr>
<td></td>
<td>Gluteus medius</td>
<td></td>
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<tr>
<td></td>
<td>Piriformis</td>
<td></td>
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<tr>
<td></td>
<td>Ober test</td>
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<td></td>
<td>Guanche instability test</td>
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<tr>
<td>Prone</td>
<td>Internal rotation &amp; external rotation</td>
<td>Domb instability test</td>
</tr>
</tbody>
</table>

**Figure 1:** The basic hip examination in tennis players – efficient screening examination of the hip in athletes, minimising patient movement other than the hip, ROM=range of motion, FADIR=flexion adduction internal rotation.
splinting or compensating for the injured limb. Patients with piriformis syndrome may lean off the affected hip, while some patients with FAI or anterior labral tear may slouch in the chair to reduce hip flexion. Antalgic gait, with decreased stance phase, shortened swing phase or avoidance of hip extension is noted. Also, Trendelenburg gait may be seen because of abductor weakness or as the patient tries to place their centre of gravity over the hip, reducing the forces on the joint. Leg lengths are measured standing – assessing from the back for pelvic tilt and can be done in conjunction with the Trendelenberg test looking for abductor weakness (Figure 2).

Palpation
Intra-articular pathologies usually do not have palpable areas of tenderness, although compensation for longstanding intra-articular problems may result in muscular or bursal pain. Palpation over the site of pain can help delineate whether the pain is deep, muscular or bursal related.

Range of motion
It is important to evaluate active and passive hip range of motion (ROM) with the patient in the seated, supine and prone positions (Table 3). Assessment generally focuses on hip flexion, as well as internal and external rotation. Flexion contracture is measured with the Thomas Test (Figure 3). We have observed that players with a history of abdominal muscle strain have a hip flexion contracture – although cause and effect have not been concluded.

Table 3: Active normal range of motions of the hip.

<table>
<thead>
<tr>
<th>Motion</th>
<th>Range</th>
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<tbody>
<tr>
<td>Flexion</td>
<td>110° - 120°</td>
</tr>
<tr>
<td>Extension</td>
<td>10° - 15°</td>
</tr>
<tr>
<td>Abduction in extension</td>
<td>30° - 50°</td>
</tr>
<tr>
<td>Adduction in extension</td>
<td>30°</td>
</tr>
<tr>
<td>External rotation in flexion</td>
<td>40° - 60°</td>
</tr>
<tr>
<td>Internal rotation in flexion</td>
<td>30° - 40°</td>
</tr>
</tbody>
</table>

Provocative or special tests
Intra-articular pathology: with the dynamic labral stress test, or scour manoeuvre, the examiner is trying to catch a torn labrum to cause pain and/or iliopsoas-related pain (tendinitis or bursitis) may be exacerbated by testing hip flexion strength while the patient is seated (Figure 6). We have found that iliopsoas weakness is associated with abdominal muscle injuries in professional female tennis players.

Strength
Strength testing may elicit weakness as a cause of pain or compensatory loss from hip pathology. This is performed in all directions of hip motion. Specific muscles we test in most athletes with hip pain are the hip abductors and adductors, as well as hip flexors. Hip abductor weakness is assessed with the Trendelenburg test as above (Figure 2). Because adductor injuries are quite common in tennis, we assess adductor strength for different parts of the adductors by testing in hip extension and flexion (Figure 5). Iliopsoas-related pain (tendinitis or bursitis) may be exacerbated by testing hip flexion strength while the patient is seated (Figure 6). We have found that iliopsoas weakness is associated with abdominal muscle injuries in professional female tennis players.

Figure 2: Trendelenberg sign and leg length discrepancy. Evaluating the patient from the back, standing on both legs, the examiner evaluates the iliac crest heights for determination of leg length discrepancy. Then the athlete lifts one knee while the examiner still has their hands on the iliac crests and posterior iliac spines. The crest on the side the leg is lifted should rise up, indicative of good strength on the contralateral hip abductors. If it does not raise, or if the athlete shifts their upper body toward the standing leg, then there is hip abductor weakness (as seen in this figure).
catching/snapping (Figure 7). The flexion/adduction/internal rotation (FADIR) test (also known as the impingement test) may be performed in either the supine or lateral positions (Figure 8). Although the FADIR has been called the impingement test, it is very sensitive for intra-articular hip pathology, not necessarily just FAI and may also provide false positive results.

Groin pain provoked by dynamic tests as well may suggest an intra-articular source of pain – the McCarthy (Figure 9) and Stinchfield (Figure 10) tests. Pain with the Stinchfield test may be indicative of intra-articular source of pain, though many extra-articular pathologies, such as hip flexor strains, may also produce a positive result.

The foveal distraction test is performed with the patient in the supine position. The leg is abducted 30° and axial traction is placed on the leg. This manoeuvre reduces intra-articular pressure and relief of pain is indicative of an intra-articular source of hip pain.

The log roll test is a sensitive manoeuvre to evaluate for intra-articular pain for those with acute hip injuries. A modified log roll test evaluates for hip instability. With the patient supine and their lower extremities relaxed, the external rotation position of the foot is noted. The foot is passively internally rotated by the examiner and let fall back into external rotation. This may provide

**Figure 3:** Thomas Test. Utilised to evaluate for hip flexion contractures. If there is no flexion contracture, the extended hip and extremity will be flat on the examination table. Care is taken to be sure the lumbar spine is flat against the examination table during this test, and can be assessed by the examiner placing their hand between the athlete’s lower back and table or using a pneumatic cuff to evaluate the pressure exerted by the back at the table.

**Figure 4:** Ober Test. This test is for hip abductor tightness or iliotibial band contracture. It is performed with the patient in the lateral decubitus position. The hip and knee are first flexed, then the hip abducted, then extended and let fall into adduction. Inability of the knee to drop below neutral is considered positive, or tightness of the iliotibial band.

**Figure 5:** A method to test adductor strength with resisted adduction – this test is performed in extension, as shown here, and in flexion, with the hips and knees bent approximately 90° each.

**Figure 6:** Iliopsoas strength test – Resisted hip flexion while seated is useful to evaluate the iliopsoas for weakness as well as pain.
a clue to iliofemoral ligament laxity or anterior instability.

Evaluating the hip for microinstability is quite difficult due to the deep and constrained nature of the hip. However, microinstability is not uncommon in tennis players due to the repetitive and forceful nature of the twists and turns, using the hip as a fulcrum. The hyperextension external rotation test evaluates for an anterior labral tear and/or instability of the hip (Figure 11). Other tests include the prone instability test described by Domb\(^6\) where the hip is externally rotated while the examiner presses anteriorly on the posterior greater trochanter, and the lateral positioned instability test described by Guanche\(^7\) where the patient is in the lateral decubitus position and the affected hip is abducted, extended and externally rotated while applying an anterior force to the posterior greater trochanter, resulting in anterior hip pain.

Extra-articular pathology: many tennis players have sacroiliac joint-related pain as a primary issue and some as a result of FAI. The Patrick test (Figure 12) and the

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**Figure 7:** Labral stress test, Scour manoeuvre. With this test, the supine patient’s hip is flexed abducted and externally rotated to start (7a). The hip is then adducted and internally rotated (7b) while extending the hip (7c and 7d). The hip is then passively ranged from flexion through a wide arc of abduction and external rotation with hip extension.

**Figure 8:** The flexion/adduction/internal rotation (FADIR) ‘impingement’ test. Here the hip is flexed to 90°, then adducted, and then internally rotated. While this test is called the impingement test, it is not pathognomonic for femoroacetabular impingement but is sensitive for other sources of intra-articular hip pathology.

**Figure 9:** McCarthy Test. The McCarthy Test is performed by having the supine patient start with maximum hip flexion, adduction, and internal rotation moving to full extension, then immediately moving into maximum flexion, abduction, and external rotation moving to full extension, causing pain. The other leg is held in flexion to help stabilise the pelvis.
Gaenslen’s test (Figure 13) are beneficial to evaluate the sacroiliac joint.

Osteitis pubis often occurs in tennis players and can be diagnosed by tenderness to palpation at the pubic symphysis, as well as pain with a pelvic compression test, performed with the athlete supine or lateral. Additionally, the pubic symphysis stress test may elicit pain at the pubic symphysis. With the patient supine, the examiner grabs the superior border at one side of the pubis and the inferior border of the pubis on the contralateral side. The two hands are then pressed together, creating a shearing force at the pubic symphysis. A positive test will reproduce the patient’s pain at this location. Pain with the resisted sit-up test is helpful in evaluating for athletic pubalgia. A positive test produces pain at the rectus abdominus insertion or in the groin.

With external snapping hip (coxa saltans externa), the iliotibial band violently snaps over the greater trochanter, which is usually easily seen. Most patients can voluntarily produce this snapping while standing and shifting their hip laterally. This may also be demonstrated with the patient lying in the lateral position and using the upper leg to simulate a bicycle pedalling motion and a positive test will reproduce snapping of the iliotibial band. Internal snapping is usually audible as the iliopsoas is suddenly forced under

**Figure 10:** Stinchfield test. This test is performed with a straight leg raise against resistance. This can be an effective screening tool for intra-articular hip pathology or hip flexor inflammation or injury.

**Figure 11:** The Hyperextension External Rotation Test. This test evaluates for anterior pain when a supine patient’s pelvis is at the end of the examination table, and their lower extremities are dangling free. The hip not being examined is flexed and held by the patient while the other extremity is externally rotated while in hyperextension. Anterior pain may be the result of an anterior labral tear and/or anterior microinstability.

**Figure 12:** Faber test/Patrick’s test. In this test, the patient’s buttock is off the edge of the table, and then the ipsilateral leg is brought into a ‘figure-of-4’ position (Flexion, Abduction and External Rotation – FABER). While stabilising the contralateral pelvic brim/anterior superior iliac spine with one hand, the examiner applies a downward force to the knee with the other hand. Posterior pain is often elicited as a result of sacroiliac pathology, while anterior pain may be the result of pubic symphysis pain or anterior labral damage.

**Figure 13:** Gaenslen’s test. For the Gaenslen’s test, the patient’s buttock is off the edge of the table and then the ipsilateral leg is extended off the edge of the table. This manoeuvre stresses the sacroiliac joint and is positive if the patient experiences posterior hip pain on the provoked side.
tension over the iliopectineal eminence or the femoral head. The snap can be elicited with the supine patient actively taking their flexed hip into abduction, external rotation and extending it and internally rotating it. However, painless snapping is very common in certain sports, including tennis, and may not be the player’s source of pain.

To test for piriformis syndrome, the patient is examined in the lateral decubitus position and a resisted external rotation of the flexed hip may reproduce their pain. Additionally, while the patient is in this position, the piriformis is palpated to elicit tenderness (compared to the contralateral side). Another test we have found useful to detect athletic pubalgia is the Hesselbach’s test (Figure 14).

**Imaging and procedures**

**Plain radiographs**

Routine radiographs should be obtained in all patients with hip pain. Plain hip radiographic series includes an anteroposterior (AP) view of the pelvis, an AP view of the affected hip and a lateral view of the hip. The AP view of the pelvis is imperative because most of the radiographic lines and relationships have been validated with the AP pelvis view. Additionally, the AP pelvis radiograph allows visualisation of closely related areas that may present with hip pain, such as the pubic symphysis, sacrum, sacroiliac joints, ilium and ischium (Figure 15).

It is important to obtain an orthogonal view to the AP radiograph. Several lateral

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**Figure 14:** Hesselbach’s test. Palpating the edge of the rectus abdominus near its insertion while the patient does a sit up is a test that is helpful to evaluate for a sports hernia. Exacerbation of symptoms with this provocative manoeuvre is consistent with athletic pubalgia/sports hernia.

**Figure 15:** Routine appropriate AP pelvis radiograph. This is an AP pelvis radiograph of an ATP player with symptomatic FAI. An appropriate AP pelvis radiograph is confirmed by the tip of the coccyx being centred 1 to 3 cm above the pubic symphysis. An AP view of the pelvis can be helpful because it allows comparison with the asymptomatic side to evaluate subtle variations in bony architecture as well as allowing visualisation of closely related areas that may present with hip pain. Furthermore, measurements and relationships of pelvic bony structures have been validated with AP pelvis radiographs and not just AP of the hip. This player has bilateral loss of femoral head neck offset seen in cam impingement as well as a crossing sign of pincer impingement, FAI=femeroacetabular impingement.

**Figure 16:** MRI of an ATP player with a perilabral cyst consistent with a labral tear. Arrowhead points to the labral cyst.

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**Hip injuries are being more frequently recognised in high level tennis players**
Tennis is a sport where the hip is taken through its extremes of motion, subjecting the joint and its associated soft tissue structures to high and potentially injurious forces.
views may be obtained, including a cross table lateral, a Dunn View, modified Dunn View, frog table lateral and false profile view. The cross table lateral radiograph is generally preferred, as it is an easy to obtain, reproducible lateral view of the proximal femur and acetabulum.

Plain radiographs may help identify degenerative joint changes, osteonecrosis, loose bodies, stress fractures and osseous pathology, such as dysplasia or FAI. While labral tears are usually not seen on plain radiographs, the majority of patients with labral tears have associated bony abnormalities.

MRI

MRI has traditionally been used to evaluate soft-tissue injury, such as labral tears, subchondral cysts, bursitis and tendinous injuries (Figures 16 - 18). MRI has also been found to be useful in the early detection of stress fractures of the femoral neck and osteonecrosis. The routine use of MRI in assessing labral injuries has been questioned by some because of the relatively low sensitivity and specificity of MRI. In particular, MRI of the pelvis has a very low sensitivity to detect labral tears as compared with an MRI of the hip (a smaller field of view). False-positive results may also occur with MRI. Newer techniques and more powerful magnets have increased the ability to detect labral tears as well as isolated chondral defects.

MRI arthrography

MRI combined with arthrography appears to increase the utility of this imaging modality in the diagnosis and description of labral pathology (Figure 19) and articular cartilage loss (Figure 20). MR arthrography is more sensitive than MRI in detecting labral and cartilage injury, though there is a high rate of asymptomatic labral tears and thus clinical correlation is imperative. The addition of local anaesthetic with the gadolinium intra-articular contrast can assess pain relief in addition to identification of anatomic evidence of intra-articular pathology and can help confirm the pain source is within the joint. If there is no relief with the intra-articular injection, other sources of pain must be considered.

SUMMARY

Hip injuries are being more frequently recognised in high level tennis players, with up to a quarter of injuries occurring in the pelvis/hip/groin. The evaluation of the tennis player’s hip starts with a good history and physical examination. This will usually help differentiate whether the pain is intra-articular or extra-articular. Plain radiographs (AP pelvis and lateral of the affected hip) are usually helpful. If an intra-articular source of pain is suspected, an MRI arthrogram of the affected hip is the diagnostic modality of choice. Anaesthetic should be included with the contrast for the arthrogram, to help confirm if intra-articular findings are the source of pain. If the pain is peri-articular, then arthrography is generally not necessary.

References


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