

Long-Term Evaluation of the Elmslie-Trillat-Maquet Procedure for Patellofemoral Dysfunction

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ABSTRACT

We evaluated 55 knees in 51 patients after Elmslie-Trillat-Maquet procedures. The procedure involves medialization of the tibial tubercle on a distal pedicle and elevating the tibial tubercle anteriorly 10 mm with a local bone graft. At a mean followup of 74.2 months (range, 13 to 196), all patients completed postoperative surveys and 38 underwent postoperative examinations. Subjectively, 9 knees (16%) had excellent results, 24 knees (44%) obtained good results, and 13 knees (24%) had fair results for a total of 84% improvement overall. Using Fulkerson's functional knee score, 19 knees (35%) had excellent results, 10 knees (18%) had good results, and 11 knees (20%) had fair results for a total of 73% improvement overall. A total of 24 knees (44%) required later screw removal. The most significant findings of this study include 1) an 84% overall subjective improvement in symptoms; 2) the findings that young patients without evidence of progressive osteoarthritis and with patella instability as a primary symptom tend to have the most favorable outcome; and 3) 24 knees (44%) required later screw removal.

The management of patellofemoral pain and instability unresponsive to nonoperative measures remains controversial.^{22,27} Multiple surgical procedures have been described with no consensus on optimal therapy. Furthermore, no studies have evaluated characteristics of patient

selection to identify those who might benefit most from surgical interventions. Accordingly, the purpose of the present study is to describe and evaluate a surgical technique developed by the senior author (JST) for patients with patellofemoral pain or instability or both and to outline the risk factors that may affect the ultimate outcome. The technique is a combination of the Elmslie-Trillat procedure, which essentially medializes the tibial tubercle, and the Maquet procedure, which elevates the tibial tubercle anteriorly (Fig. 1).

MATERIALS AND METHODS

A total of 55 knees in 51 patients were retrospectively reviewed after Elmslie-Trillat-Maquet procedures. All surgical cases were performed by the senior author (JST). The indications for surgery included a skeletally mature patient with symptoms of patellofemoral pain or dislocation or both who failed to respond to at least 3 to 6 months of nonoperative therapy. All patients had abnormal Q angles of more than 15°. The diagnosis of patellar subluxation or dislocation was made on the basis of the history, presence of a hemarthrosis without evidence of ligamentous instability, and the ability of the examiner (JST) to passively subluxate or dislocate the patella and reproduce the patient's subjective experience of instability.

The mean age of the patients at followup was 27.5 years (range, 17 to 40). There were 21 men and 30 women in the study. Thirty operations were performed on the left knee, and 25 on the right. Preoperatively, patients reported patellofemoral pain and instability as primary symptoms in 17 and 24 knees, respectively; both patellofemoral pain and instability were reported in 14 knees. The total number of preoperative subluxations or dislocations was distributed as follows: none in 11 knees (20%); 1 in 5 knees (9%); 2 to 5 in 12 knees (22%); 6 to 20 in 11 knees (20%); and more than 20 in 16 knees (29%). An analysis of pa-

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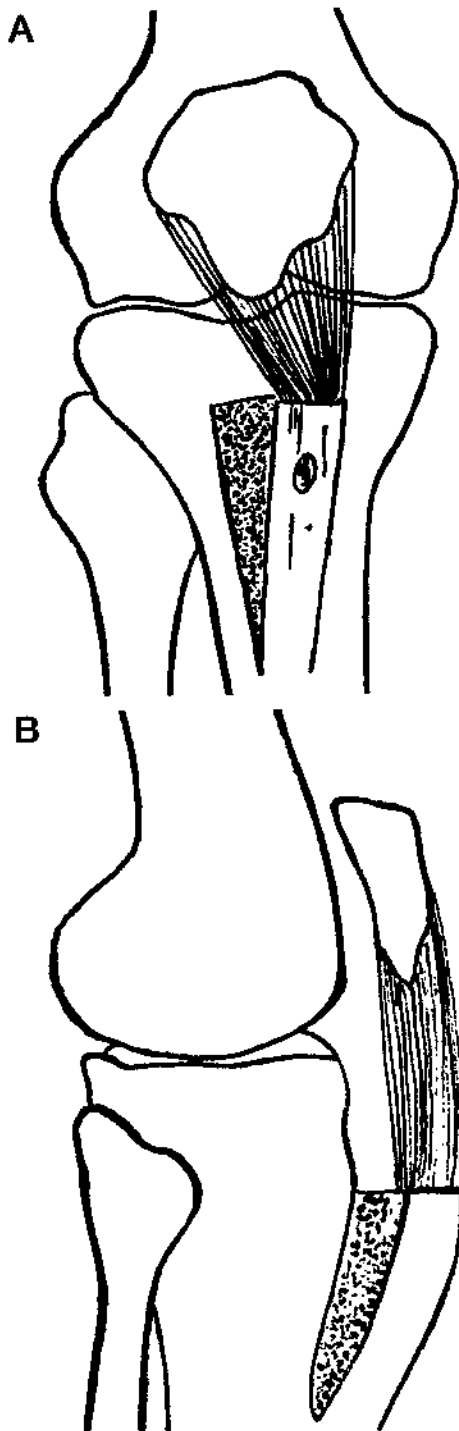


Figure 1. A, line drawing demonstrating the lateral-medial displacement of the osteotomized tibial tubercle pedicle (Elmslie-Trillat portion of the procedure). B, line drawing demonstrating 1-cm elevation affected by placement of corticocancellous graft obtained from original osteotomy site (Maquet portion of the procedure).

tients based on age, sex, or side of operation was not statistically different between groups primarily reporting pain, instability, or both pain and instability. Pain severity was significantly higher in patients reporting primarily pain, or pain and instability, versus patients reporting primarily instability alone. As expected, the number of instability episodes was higher in patients reporting primarily instability.

All patients underwent arthroscopic examination at the time of surgery, and they had each of three knee compartments (medial, lateral, patellofemoral) evaluated for chondromalacia. Grade 0 chondromalacia was a normal appearance; grade I chondromalacia was cartilage softening; grade II was fibrillation; grade III cartilage was fissuring or partial thickness loss; and grade IV chondromalacia was characterized by erosion of articular cartilage down to subchondral bone.

The time from surgery to followup averaged 74.2 months (range, 13 to 196). At followup, a subjective evaluation and an objective Fulkerson functional knee score were used to assess outcome.¹⁶ In the subjective evaluations, patients were asked to rate the results of their surgeries based on the following criteria: 1) excellent, the knee has markedly improved and the patient returned to all activities; 2) good, the knee has improved, but there still is occasional discomfort or problems with participation in sports activities; 3) fair, the knee has improved, but the patient still has problems with participation in sports activities. The patient has no problems performing daily activities; and 4) poor, the knee is no better or worse than before surgery. The Fulkerson functional knee score is based on Lysholm's functional scoring system for knee ligament surgery but has been modified for patients with patellofemoral pain or instability or both. The modified system is based on 100 points and comprises seven categories: gait, ambulation support, stair climbing, squatting, instability, pain, and swelling.¹⁶ The scores are graded as follows: excellent, 90 to 100 points; good, 80 to 89 points; fair, 70 to 79 points; and poor, less than 70 points.

Postoperative examination of 38 knees by the senior author included a bilateral lower extremity analysis of gait, atrophy, range of motion, apprehension and Sage signs, patellar inhibition and tilt tests, presence of effusion, patellar grind and crepitation, and measurements of Q angle and tuberosity-sulcus angle. A positive apprehension test was noted if a patient developed appreciable anxiety with attempts at lateral subluxation of the patella. A positive apprehension test is a sign of probable subluxation or past dislocation of the patella. The Sage sign, named after the Australian orthopaedic surgeon, John Sage, MD, is performed with the patient supine and the involved knee supported in 20° of flexion. A medially directed fingertip force is applied manually by the examiner. Medial patellar excursion of less than 25% of the greatest patellar width is considered a positive sign and indicates tight lateral parapatellar soft tissue structures.¹⁸ The patellar inhibition test is performed with the patient supine and involves placing a resistive force at the superior aspect of the patella while the patient attempts

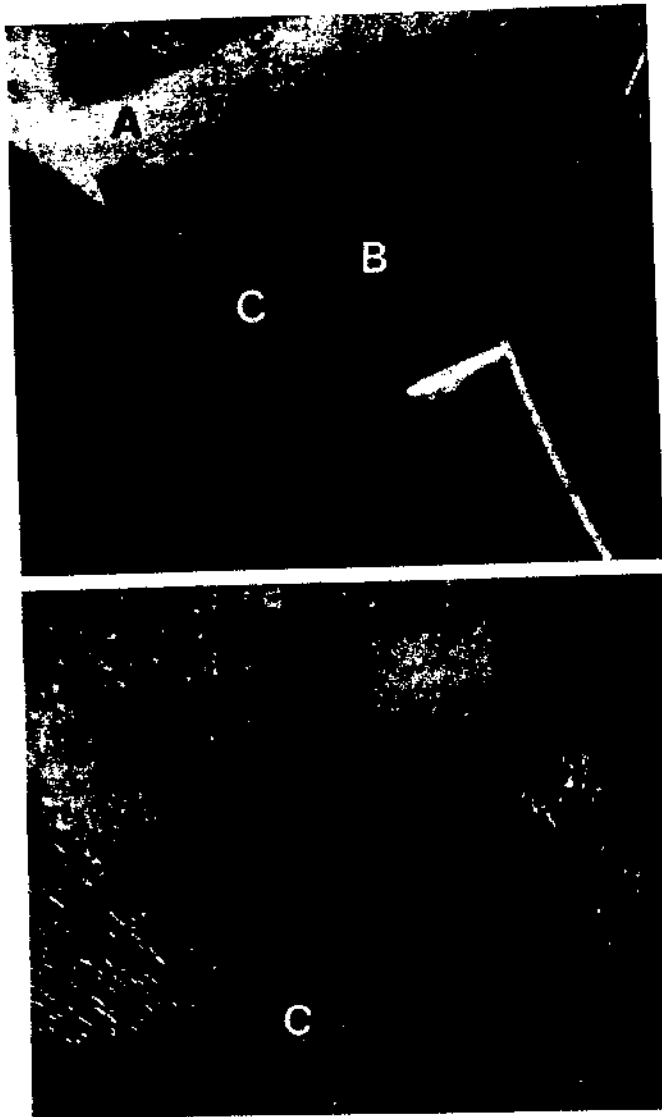


Figure 2. Top, the graft is isolated with a saw (A, tibial tubercle; B, graft; C, saw). Bottom, the graft is removed with osteotome (A, tibial tubercle; B, graft; C, osteotome).

to contract the quadriceps muscle. A positive test is demonstrated by the presence of pain and subsequent failure to extend the knee. Patellar tilt is determined with the involved knee in full extension. With a normal lateral retinaculum, the patella may be tilted to approximately 10° above the horizontal plane.

The Q angle is an estimate of extensor alignment and is represented by a line from the anterosuperior iliac spine through the midpoint of the patella to the tibial tuberosity with the knee in full extension. An angle more than 15° in women and more than 10° in men is considered abnormal. The tuberosity-sulcus angle is between the distal pole of the patella and the tibial tuberosity at 90° of knee flexion compared with a vertical line. Normally, the tibial tubercle is directly inferior to the distal pole of the patella at this angle of knee flexion. Patellar grind and crepitation is



Figure 3. Graft of 10 mm thickness.

determined by firm compression of the patella into the trochlea at various degrees of flexion. Reproduction of symptoms may suggest possible sites for articular degeneration.

Statistical analysis included the *t*-tests for numerical data and chi-square tests for nonparametric data; *P* values less than 0.05 were considered statistically significant.

Surgical Technique

The patient is placed supine on the operating room table. Examination with the patient under anesthesia is then performed. After standard sterile surgical preparation, application of a drape, and arthroscopic diagnosis, a lateral curvilinear incision is made from the lateral distal pole of the patella to the medial tibial tubercle with the knee controlled by a pneumatic tourniquet. This incision is carried down through the infrapatellar fascia with identification of the infrapatellar tendon. Subcutaneous lateral release is performed. The vastus lateralis tendon is identified as it inserts into the superolateral aspect of the patella and is preserved. The release begins distally at the tibial tubercle, runs proximally, and parallels the lateral border of the patella to extend just proximal to the superior pole of the patella. The release includes both the capsule and retinaculum but does not include the synovium.

The periosteum and muscles of the anterior compartment are then stripped from the tibia for a depth of approximately 10 mm. Then, using a microsagittal saw, the tibial tubercle is cut at its superior, medial, and lateral borders, with subsequent elevation of the tubercle with an osteotome. Distally, the bone is fractured with the periosteal sleeve remaining intact. The pedicle is then displaced medially to correct the Q angle to 0° , and a 1-cm thick bone graft is obtained from the original tibial tubercle location and placed underneath the displaced tubercle (Figs. 2 and

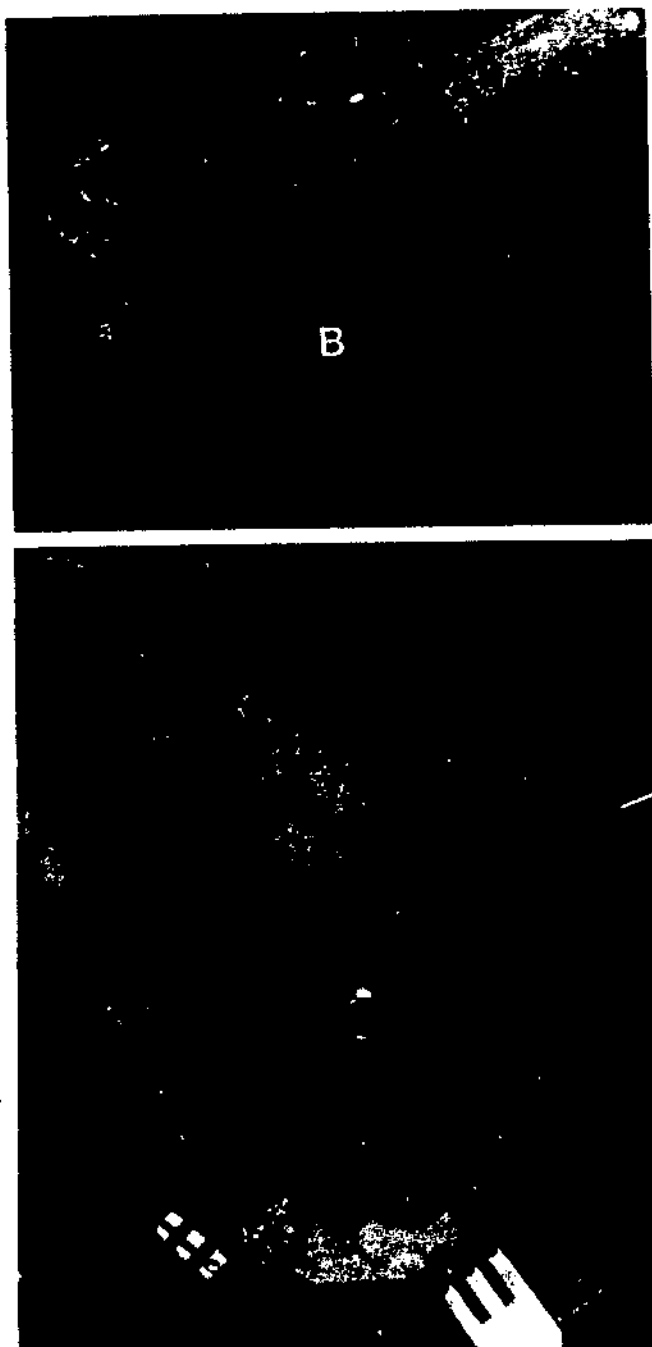


Figure 4. Top, lateral view of tibial tubercle, fixed anteromedially, demonstrating anterior elevation (A, tibial tubercle; B, graft). Bottom, anteroposterior view of tibial tubercle, fixed anteromedially, demonstrating medial translation.

3). The tubercle is then overdrilled using a 4.5-mm drill, followed by drilling with a 3.2-mm drill. Then, after tapping, a cortical screw, appropriately 4.5 mm in size, is placed (Fig. 4). The knee is then placed through a range of motion to demonstrate normal tracking and good stability of the tibial shingle. Distal medial reefing is done if passive subluxation of the patella persists after taking the

knee through a range of motion. The distal fascia adjacent to the infrapatellar tendon and inferior patellar periosteum is imbricated in a pants-over-vest fashion (19 knees). The vastus medialis obliquus muscle is advanced in the direction of its fibers and sutured to the patella with nonabsorbable sutures if complete passive patellar dislocation persists (three knees). The wound is then closed in layers over a medium-sized Hemovac drain (Zimmer Inc., Warsaw, Indiana).

Postoperatively, the patient's leg is placed in a brace locked at 20° and partial weightbearing is allowed using crutches. At the 1-week followup, the sutures are removed, weightbearing is progressed, and quadriceps muscle isometric exercises are initiated in the brace, with passive range of motion exercises in the brace several times daily. At 6 to 8 weeks, more aggressive strengthening and range of motion may be instituted with gradual return to normal activities. In the later cases, patients used a continuous passive motion machine immediately after surgery for a duration of 1 week.

RESULTS

Subjectively, there were 9 knees (16%) with excellent results, 24 knees (44%) with good results, and 13 knees (24%) with fair results. This amounted to 46 knees (84%) with improvements over their preoperative statuses over the 74.2-month average follow-up period. Using Fulkerson's functional knee score, 19 knees (35%) had excellent results, 10 knees (18%) had good results, and 11 knees (20%) had fair results.

Results, based on each patient's chief symptom, demonstrated that those with a primary symptom of pain had an average Fulkerson score of 74. Patients with a primary symptom of instability had an average score of 82, and those who reported both pain and instability had an average score of 75.

An analysis of several individual factors revealed a preoperative pain severity rating of 7.2 based on a scale from 1 to 10. Postoperatively, the pain rating significantly improved to an average of 4.2 ($P < 0.05$). Postoperatively, there were no dislocations in 49 knees (89%); 1 dislocation in 4 knees (7%); and 2 to 5 dislocations in 2 knees (4%).

There was a significant difference between the mean age in years of patients with excellent (24.6) and good (26.2) results compared with those who obtained fair (30.1) or poor (31.5) results ($P < 0.05$).

A primary symptom of instability over pain also appeared to portend a better outcome. This is supported by the better results that were obtained in patients who had more than two preoperative dislocations versus those who had only one or none. The average Fulkerson score for those with 0 to 1 dislocations was 67, compared with 82 for patients with more than 2 preoperative dislocations ($P < 0.05$).

Degenerative changes of other knee compartments were also found to be a poor prognostic predictor for success of this procedure. This is demonstrated by the presence of a significant difference between groups after grading the medial and lateral tibiofemoral compartment arthroscopic

cally. The patients with better surgical outcomes possessed significantly fewer medial and lateral tibiofemoral compartment changes compared with those who did poorly ($P < 0.05$). No difference in outcome was detected with regard to patellar compartment changes.

Postoperatively, the physical examination findings associated with patellofemoral pain, such as from the patellar inhibition ($P < 0.05$) and patellar grind tests ($P < 0.05$), were associated with poorer outcomes.

We have identified certain risk factors, i.e., age >31.5 years, fewer than two dislocations, and medial or lateral tibiofemoral compartment chondromalacia more than grade 1; the presence of two or more of these conditions is also associated with a less desirable outcome ($P < 0.05$).

Comparisons of the population of patients studied for fewer than 36 months showed 92% improvement overall. This is significantly different from the 82% improvement rate obtained in the group of patients with at least a 72-month followup ($P < 0.05$). There was no statistical significance in the time of followup between those patients who obtained good and excellent results versus those whose outcomes were fair or poor.

Complications included two patients who ultimately required patellectomies for continued pain. Six knees had recurrent dislocations. Screw discomfort necessitated removal of screws in 24 patients (47%). There were no reports of skin problems or infection associated with this procedure. No patients underwent revisions of their distal realignments.

DISCUSSION

Review of the literature reveals numerous techniques designed to deal with the problem of patellofemoral pain or subluxation and dislocation or all of these conditions. Hauser,²⁰ in 1938, described medial and distal transfer of the tibial tubercle for patellofemoral instability. The technique theoretically compensates for the biomechanical tendency of the patella to dislocate laterally secondary to a valgus vector.^{25,26} The literature reports 53% to 73% good-to-excellent results with this procedure.^{1,4,8-10,14} This technique also involves distal advancement without elevation of the tibial tubercle, and long-term studies have demonstrated progression of patellofemoral degenerative changes in 70% of the knees.^{8,19} This is presumably due to an increase in patellofemoral joint reaction forces associated with the distal advancement.

The Roux procedure was originally performed by Roux³⁹ in 1888. The technique was later modified by Elmslie and published in France by Trillat et al.⁴³ in 1964. The technique involves a lateral soft tissue release, medial reefing, and medial tibial tuberosity displacement without posterior displacement of the tuberosity. Studies demonstrate 70% to 80% good-to-excellent results without evidence of progression of osteoarthritis.^{3,5-7,38,41,45,46} These results, however, must be interpreted with caution because the longest followup averages 4 years.¹⁹

The Maquet²⁹ procedure, originally described in 1963 for patellofemoral pain, involves 2- to 2.5-cm anterior displacement of the tibial tuberosity. Biomechanically, sev-

eral authors report that the procedure reduces the forces exerted by the quadriceps muscle through the patellar tendon and, consequently, decreases the force transmitted by the patella to the femur.^{25,29} Good-to-excellent results varied from 80% to 90%, with the longest followup being 16 years.^{2,11,12,21,23,24,28-30,34-37,40,42} Complications include poor skin healing secondary to the prominence created from the elevation. Modification of this procedure, i.e., with less anterior displacement (1.25 cm), as based on studies by Ferguson et al.^{12,13} and Nakamura et al.,³² has been shown to exert similar biomechanical effects in anatomic studies but with theoretically fewer skin complications.

More recently, there have been reports of a combined medial and anterior displacement of the tibial tubercle. Four different techniques have been described. Miller and LaRoche,³¹ in 1986, described isolating the tibial tubercle on a pedicle and simultaneously rotating it medially and elevating it the thickness of the tubercle pedicle. Their retrospective review of 38 knees with a minimum followup of 2.5 years reported 86% good-to-excellent results. Noll and his associates³³ reported a technique of obtaining a bone block attached proximally to the patellar tendon and transferring it to a bed on the tibia in a medial location, with the elevation obtained equal to the thickness of the osteotomized segment. They demonstrated 93% fair-to-excellent results in 17 patients with a followup ranging from 1 to 4 years.

Finally, Fulkerson et al.^{15,17} described a technique involving an anteromedial tibial tubercle shift along an oblique osteotomy plane. They obtained 85% good-to-excellent results subjectively and 93% fair-to-excellent results using objective parameters in 30 knees with a 19-month average followup. Weaver et al.⁴⁴ adapted Fulkerson's technique of an oblique osteotomy to shift the tibial tubercle, and they supplemented the anteriorization with local bone graft from Gerdy's tubercle. Their results in 14 patients with an average followup of 5 years were 0% excellent, 21% good, 64% fair, and 15% failures. The overall results of this small series are comparable with the objective scores from our study.

The authors recognize that this is a retrospective study without a control population. Although all patients in the study completed a subjective evaluation of their surgeries, only 38 of 51 underwent postoperative followup examinations. The data do indicate, however, that the Elmslie-Trillat-Maquet procedure results in subjective improvement and reduces the propensity for resubluxation. Outcome did not correlate with the degree of chondromalacia present at the time of surgery, but the authors believe it would be unrealistic to expect a reversal in preexisting pathologic changes at the patellofemoral articulation with this or any other procedure attempting to deal with patellar subluxation or excessive patellofemoral pressure changes. Furthermore, the data suggest that using patient selection criteria, such as youth, absence of medial and lateral tibiofemoral compartment changes, and a primary symptom of instability, would result in a more favorable outcome.

CONCLUSIONS

There was an overall 84% subjective improvement in patients with patellofemoral pain or instability. Greater improvement was obtained during the first 3 years of followup, with a decrease occurring between Years 3 and 4. We believe this information may be helpful in counseling patients regarding the expectations of the Elmslie-Trillat-Maquet procedure. Younger patients without evidence of medial or lateral compartment degenerative changes and with the primary symptom of instability tended to have the most favorable outcomes. These factors may have a strong influence in patient selection. The presence of one or more risk factor was associated with a less desirable outcome. A relationship between chondromalacia of the patella graded arthroscopically and the final outcome of surgery was not demonstrated. Postoperative indicators of a more desirable outcome were the absence of such physical findings as positive patellar inhibition or patellar grind tests. Complications with this procedure were relatively few. Many patients required later screw removal.

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