Journal of Hip Preservation Surgery Vol. 6, No. 4, pp. 398–405
doi: 10.1093/jhps/hnz046
Advance Access Publication 14 November 2019
Research article

OXFORD

Diagnostic accuracy of a new clinical test (resisted internal rotation) for detection of gluteus medius tears

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Submitted 19 March 2019; Revised 23 July 2019; revised version accepted 3 October 2019

ABSTRACT

The objective of this study was to evaluate the diagnostic accuracy of a new dynamic clinical examination for detection of gluteus medius (GM) tears. A case group of 50 patients undergoing arthroscopy with GM repair was compared with a control group of 50 patients undergoing arthroscopy who had no peritrochanteric symptoms. Both groups were examined clinically, had magnetic resonance imaging studies performed and underwent arthroscopic surgery. Recorded clinical examinations included abnormal gait (Trendelenburg), tenderness to palpation of the greater trochanter, resisted abduction and the test being studied, resisted internal rotation. For all clinical tests, the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy rates were calculated and compared with the arthroscopic and MRI data for the case group, and the MRI data for the control group. The resisted internal rotation test had a sensitivity of 92%, specificity of 85% and diagnostic accuracy of 88% in the detection of GM tears, with a low rate of false-positive and false-negative recordings. Other traditional clinical examination tests, with the exception of Trendelenburg gait, showed inferior rates. Trendelenburg gait had a higher specificity, but much lower sensitivity. The resisted internal rotation test aides in the detection of GM pathology. Due to the good results of the resisted internal rotation test in all the diagnostic parameters, we recommend incorporating it on the physical exam of patients with hip pain.

INTRODUCTION

Greater trochanteric pain syndrome (GTPS) encompasses trochanteric bursitis, gluteus medius (GM) and minimus tendinopathy, and external coxa saltans (i.e. snapping hip) [1, 2]. Pathology of the GM may be considered a source for lateral hip pain, yet a definite diagnosis is often delayed [3–5]. As described independently by Bunker *et al.* and Kagan in the late 1990s, it has been referred to as the 'rotator cuff of the hip' [6, 7], implying important function for hip motion and stability.

The GM is a large curve fan-shaped muscle that originates at the outer edge of the iliac crest from anterosuperior iliac spine (ASIS) to the posterior superior iliac spine (PSIS) [8]. It has three distinct portions of equal volume: anterior, middle and posterior. Both the anterior and middle portions aid in hip abduction initiation while the posterior portion stabilizes the hip in gait from heel strike to full stance [9]. The GM insert at the greater trochanter by two different attachment sites: the superoposterior facet and the lateral facet [10] (Fig. 1).

Physical examination for the GM starts with examination of the gait, palpation of the greater trochanter, range of motion and hip abductors strength testing [2]. In some instances, an unclear diagnosis may result in delayed

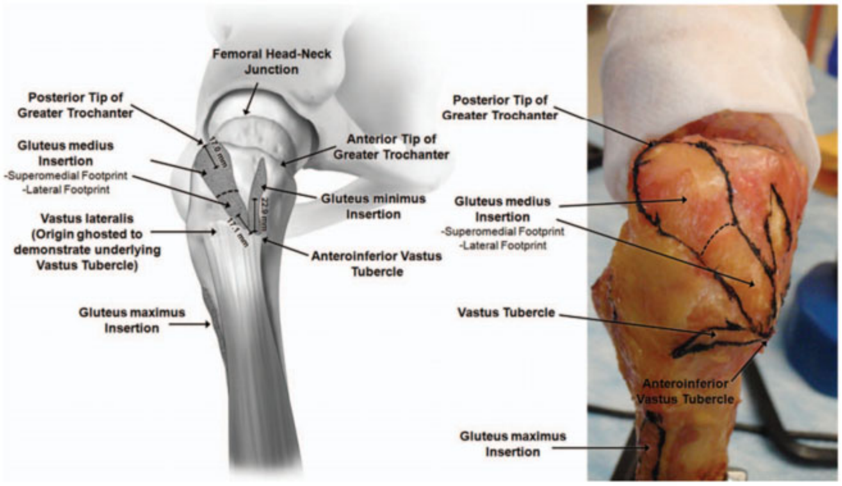

Fig. 1. (Left) Illustration and (right) photograph of lateral view of a right hip looking medially at the footprint insertions of the greater trochanter. The footprints of the gluteus medius, gluteus minimus, and vastus lateralis with respect to the vastus tubercle are depicted (Philippon *et al.* [34]).

treatment. MRI is currently the test of choice to determine pathology of the GM [11–14]. MRI has resulted in an increased diagnosis of GM tears, from interstitial to full thickness [15–20].

Recently, it has become well recognized that tendinopathy and tears of the GM are a cause of recalcitrant GTPS [3, 4, 11, 16, 17, 21–24]. Biomechanical studies have shown that the anterior fibers of the GM are only marginal internal rotators at 0 degrees of flexion, but experience a 8-fold increase in internal rotation leverage by 90 degrees of flexion [25].

This study aims to identify and describe the diagnostic accuracy of a new clinical test for detection of GM tears. The resisted internal rotation test has not been previously described and we hypothesized that it will be more sensitive, specific and accurate than other existing physical exams.

MATERIALS AND METHODS

Patients

Data from all patients treated with hip arthroscopy by the senior surgeon (BGD), between January 2015 and May 2017 were prospectively collected. Included patients underwent a complete preoperative clinical examination, MRI evaluation, and arthroscopic surgery by the senior author (BGD). Patients were excluded if they had previous hip surgery or conditions such as fractures, Legg-Calve-Perthes disease, slipped capital femoral epiphysis and avascular necrosis, Tonnis grade 2 or more and were worker's compensation. Demographic data such as sex, age, height, weight, and body max index (BMI) were recorded.

For the purpose of the study, the patients were divided in two groups. The case group included 50 consecutive patients that underwent GM repair and correction of intra articular pathology and the control group included 50 consecutive patients that had no peritrochanteric symptoms and underwent correction of intra articular pathology. This study received institutional review board approval.

Clinical examination

All patients in both groups had a thorough physical examination performed by the senior author (BGD). It included evaluation for abnormal gait (Trendelenburg), tenderness to palpation of the greater trochanter, pain with resisted abduction in the lateral position and the resisted internal rotation test.

The resisted internal rotation test (Fig. 2, video 1) is performed with the patient in the supine position with the affected hip and knee flexed 90 and the hip in 10 degrees of external rotation. With the examiner standing on the ipsilateral side of the affected extremity, the patient is asked to actively internally rotate the hip against resistance by the examiner (knee away from and foot toward examiner). One hand of the physician will be in the lateral aspect of the ankle and the other in the medial aspect of the knee to resist motion and isolate the internal rotators of the hip. The test is positive with pain reproduction and/or weakness.

Magnetic resonance imaging

Magnetic resonance imaging (MRI) is commonly used to diagnose gluteal tears. Tears are classified as tendinosis,

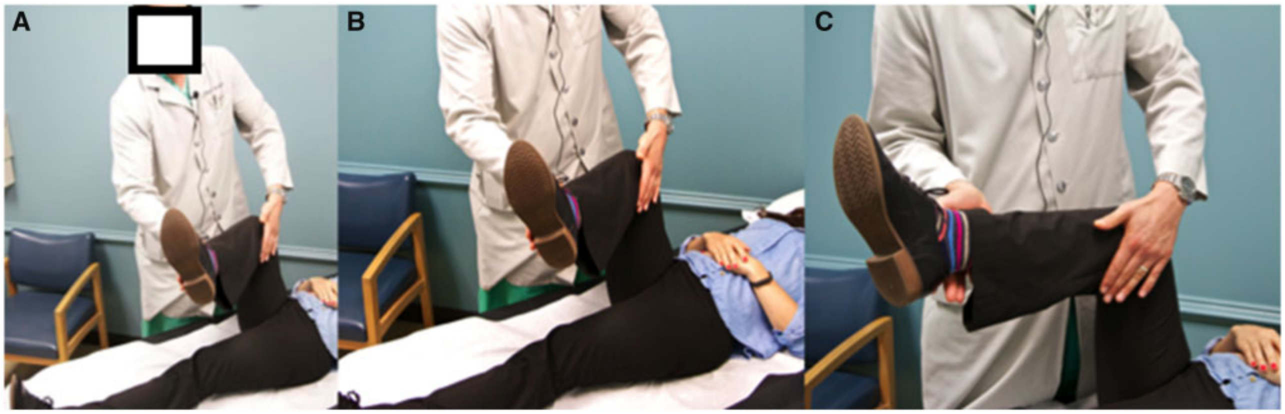

Fig. 2. (A, B, C): The resisted internal rotation test is performed with the patient in the supine position with the affected hip and knee flexed 90 and the hip in 10 degrees of external rotation. With the examiner standing on the ipsilateral side of the affected extremity, the patient is asked to actively internally rotate the hip against resistance by the examiner (knee away from and foot toward examiner). One hand of the physician will be in the lateral aspect of the ankle and the other in the medial aspect of the knee to resist motion and isolate the internal rotators of the hip. The test is positive with pain reproduction and/or weakness.

partial-thickness or full-thickness tears [18]. Tendinosis appears on the MRI as signal intensity increases on T2-weighted images [17]. A partial-thickness tear is diagnosed when the tendon is thickened and there is increased signal intensity on T2-weighted and short tau inversion recovery (STIR) images [18]. Focal discontinuity of the tendon with any degree of retraction represents a complete tear [18].

Surgical procedure

All arthroscopies were performed by the senior surgeon in the supine position on a traction extension table (Smith & Nephew, Andover, MA). Arthroscopy of the hip joint was performed first for loose bodies, chondral defects, labral tears, synovitis, ligamentum teres tears and other pathologies. If needed, Cam and Pincer lesions were addressed under fluoroscopic guidance, with femoroplasty and acetabuloplasty, respectively. Labral tears were repaired when possible; otherwise, they were selectively debrided until a stable labrum was achieved or reconstructed with allograft tendon.

For patients who required GM repair, traction was released, the leg abducted 45 degrees, and the 70 arthroscope was inserted into the peritrochanteric space through the distal anterolateral accessory portal. By aiming just inferior to the vastus ridge under fluoroscopic visualization, the surgeon avoided iatrogenic damage to the GM insertion. A shaver was then introduced through the anterolateral portal. Trochanteric bursectomy was performed, with care to keep the shaver blades away from the GM. Once the decision was made to proceed with GM repair, a posterolateral portal was created. With the assistance of fluoroscopic guidance, suture anchors were placed using different configurations depending on the size of the tear [26, 27].

Statistical analysis

The clinical examination findings were compared with MRI findings of 100 patients to calculate sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV), diagnostic accuracy for each test. In addition, the findings of the clinical examinations of the 50 patients with intraoperatively diagnosed GM tears were reviewed to determine diagnostic accuracy of the procedure. Fisher's exact test was used to determine if there was a difference between the control and case group in their peritrochanteric space MRI findings.

RESULTS

Demographics

Hundred patients with symptoms related to the hip joint were examined in the outpatient clinics, had an MRI and subsequently underwent surgery after failure of conservative management. The case group consisted of 50 consecutive patients that had endoscopic GM repair and also underwent correction of intra articular pathology. The control group consisted of 50 consecutive patients who only underwent correction of intra articular pathology.

There were statistically significant demographic differences between the case and control group. Patients in the case group were older, more likely to be female, and had higher BMI. Full demographic data can be found in Table I.

Table I. Demographics GM tear control P values

Age (years)	*58.9 ± 8.9*	*30.9 ± 14.2*	*<0.001*
Sex			<0.001
Female	45 (90%)	29 (58%)	
Male	5 (10%)	21 (42%)	
BMI (kg/m^2)	29.0 ± 4.3	24.0 ± 4.2	<0.001
Operative hip			0.840
Left	21 (42%)	22 (44%)	
Right	29 (58%)	28 (56%)	

The prevalence of GM tears in the MRI findings of the case group was significantly different when compared to the control group using the Fischer's exact test ($P < 0.0001$).

Findings

The sensitivity, specificity, PPV, NPV and DA of each clinical test, with MRI used as the method to determine GM pathology, are shown in Table II. Of all the clinical tests, the resisted internal rotation test had the highest sensitivity, NPV and DA for GM tears. Trendelenburg gait had higher specificity and PPV than the resisted internal rotation test, but had much lower sensitivity, NPV and DA. Overall, the resisted internal rotation test demonstrated good diagnostic value, with sensitivity, specificity, PPV, NPV and DA all near 90% when MRI was used to confirm the disorder. The specific findings of the resisted internal rotation test can be found in Table III. In addition when diagnostic accuracy was calculated for each clinical test using the case group intra operative findings, the resisted internal rotation test showed similar results to MRI (88%).

Two patients in the case group had MRI reported as intact GM tear, but during endoscopic procedure a tear was found and repaired. Both of them had peritrochanteric pain symptoms with a positive resisted internal rotation test.

DISCUSSION

The resisted internal rotation test is a sensitive (92%), specific (85%) and accurate (88%) test for detection of GM tears. This test complements the previously described physical exam tests and can be used to promptly reach a diagnosis. GM tears diagnosis and management have emerged recently in the field of hip preservation surgery and it is common for patients of this type to visit multiple physicians before a definitive diagnosis is made.

Table II. Sensitivity, specificity, PPV, NPV and DA for all clinical tests

	Trendelenburg gait	*GT tenderness*	*Resisted abduction*	*Resisted IR test*
Sensitivity	31%	88%	73%	92%
Specificity	100%	75%	87%	85%
PPV	100%	76%	83%	85%
NPV	61%	87%	78%	92%
DA	67%	81%	80%	88%

Table III. Clinical findings of the resisted internal rotation test for GM tears

	Positive (standard)	*Negative (standard)*	*Total*
Positive (test)	44 (a)	8 (b)	52 ($a + b$)
Negative (test)	4 (c)	44 (d)	48 ($c + d$)
Total	48 ($a + c$)	52 ($b + d$)	100

a, true positive; *b*, false positive; *c*, false negative, *d*, true negative.

Our results, in regards to demographics, are consistent with current literature—GM pathology is more common in females with a higher incidence in the fourth–sixth decade [7, 8, 11]. In addition, patients in the case group had a significantly higher BMI. Further research is needed to determine if increased BMI is a risk factor for GM tears.

The resisted internal rotation test has not been described previously in the literature and has been used in our practice for the last 3 years. The rationale for the test comes from previous biomechanics studies describing the function of the GM as an internal rotator. With the hip flexed 90 degrees, the internal rotation torque potential of the internal rotator muscles dramatically increases [25, 28–30]. As depicted in Fig. 3, the anterior fibers are only marginal internal rotators at 0 degrees of flexion, but experience an 8-fold increase in internal rotation leverage by 90 degrees of flexion [25, 28].

Two previous studies have done tests that measure resisted rotation of the hip. Bird *et al.* found that resisted internal rotation had a 54.5% sensitivity and 69.2% specificity [11]. They performed the exam with the patient supine and at 45 degrees of hip flexion and maximal external rotation. In our study we did the resisted internal rotation test at 90 degrees of flexion with 10 degrees of external rotation, a position where the torque of the

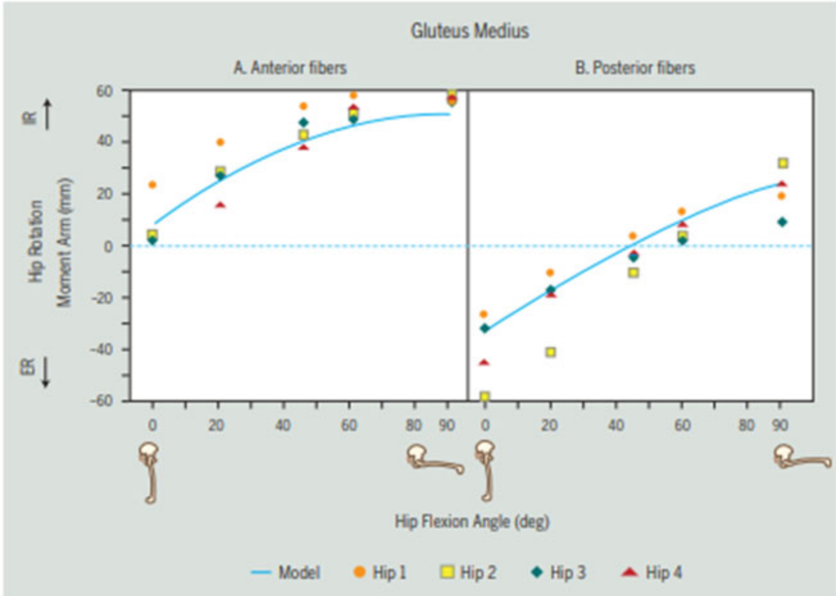

Fig. 3. Horizontal plane rotational moment arms (in millimeters) for 2 sets of fibers of the gluteus medius, plotted as a function of flexion (in degrees) of the hip. IR, internal rotation moment arm; ER, external rotation moment arm. The 0° flexion angle on the horizontal axis marks the anatomic (neutral) position of the hip. Graph created from data published by Delp et al., using 4 hip specimens and a computer model (Delp *et al.* [25]).

GM will be higher than at 45 degrees [25, 28]. Also, it is not described how internal rotation was isolated, therefore it is not clear if in addition to external rotation there was hip abduction depending on the examiner's control of rotation. In addition to doing the test differently, our study had a higher number of patients (50 versus 24), and a control group (50 patients) with patients that lacked peritrochanteric symptoms, which may explain our higher sensitivity and specificity (92% and 85%, respectively).

Lequesne *et al.* described clinical tests for gluteal tendinopathy in refractory cases of GTPS [31]. A group of 17 patients with symptomatic gluteal tendinopathy was compared to a control group of 20 (38 hips) asymptomatic volunteers. On all patients, resisted external derotation (resisted realignment of the externally rotated hip) was performed with the patient supine, the hip and knee flexed at 90 degrees and the hip in near maximal external rotation. If the test was negative, they repeated it with the patient lying prone, hip extended and knee flexed. They had a sensitivity of 88% and specificity of 97.3%. Compared with the resisted internal rotation test, the resisted external derotation test places the hip in significantly more external rotation prior to asking the patient to actively internally rotate. This suggests that at or near maximal external rotation, intra articular pathology may be the source of pain. They performed the physical exam with both hands of the examiner in the lateral knee and ankle, therefore there is no isolation of the internal rotators at 90 degrees, due to hip abduction being performed by the patient. Other limitations of this study include a small number of patients, the lack of complete diagnostic parameter values (PPV, NPV and DA), and lack of an MRI in the control group. Taking these variables in consideration may represent the difference in our study having a lower specificity (85% versus 97%).

Literature has previously described Trendelenburg gait, greater trochanteric tenderness to palpation and decreased abduction strength as clinical features that predict operative intervention for GM tears [3, 32]. In addition Chandrasekaran *et al.* found that reduced power of resisted abduction and the presence of gait deviation on initial evaluation of patients with GM tears increases in a 15-fold higher the likelihood of surgical intervention [32].

In our study, the presence of a Trendelenburg gait was 100% specific. However, it also had a 31% sensitivity, i.e. when the disease is present there is a low probability that the test will result positive. This low sensitivity can be explained by Trendelenburg gait possibly being present with more advanced disease of the GM.

Tenderness to palpation of the greater trochanter was 88% sensitive and 75% specific. This may be explained by 11 patients in the control group with tenderness to palpation in the greater trochanteric area. Previous studies have shown that the presence of greater trochanteric tenderness is not associated with increased likelihood of surgical intervention [32] and specificities of 66% [31].

Resisted abduction test performed with the patient at the lateral decubitus position had a 73% sensitivity and 87% specificity. This test is helpful and should be used in conjunction with the more sensitive and specific resisted internal rotation test. It has been shown that patients with decreased power in hip abduction are more likely to fail non operative management [32].

Several factors have been found to delay the diagnosis of GM tears. First, the clinical presentation may vary, and a correct diagnosis may not be considered initially. In addition, the absence of radiographic findings may contribute to this delay. Domb *et al.*, in a study evaluating outcomes after endoscopic GM repair, found that time to diagnosis in the case series was 38.7 months [33]. Therefore, the resisted internal rotation test is a useful tool for detection and treatment of GM tears.

A strength of the current study is the number of patients included (100 patients) that was then divided in a case (50 patients) and control group (50 patients). This is the first study to describe this physical exam using the MRI as diagnostic tool for both groups and using the arthroscopic findings for the case group. In addition, it demonstrates good results for all diagnostic parameters used in the study.

Potential future studies to determine if there is a prognostic value in determining who would and would not respond to conservative treatment and who is and is not more likely to need to go on to surgical intervention using the resisted internal rotation test are needed, and would be beneficial for better assessment of GM pathology.

Limitations

There are several limitations in this study. First, patients who had open GM repairs were not included. Our purpose was to test the utility a physical exam that can identify early GM tears. When open GM repairs are performed in our practice, patients experience significant retraction and/or muscle atrophy and usually do not represent the findings of those with smaller tears. Another limitation is the lack of a non-surgical asymptomatic control group that could help exclude a possible relationship between the symptoms of the clinical exams and intra articular pathology. Lastly, it needs to be determined if resisted internal rotation test increases the likelihood of surgical intervention.

CONCLUSIONS

The resisted internal rotation test aides in the detection of GM pathology. This study provides another tool to aid in establishing the clinical relevance of abductor tendon pathology which may be present in a setting of other simultaneous problems inside and outside the joint that can obscure the involvement of the abductor tendons. Due to the good results of the resisted internal rotation test in all the diagnostic parameters we recommend incorporating it on the physical exam of patients with hip pain.

ACKNOWLEDGEMENTS

This study was performed at the American Hip Institute. This study was approved by the Institutional Review Board (IRB ID: 5276).

FUNDING

No specific funding was received for this study.

CONFLICT OF INTEREST STATEMENT

The authors report the following past and present conflicts of interest: Dr. Domb reports grants and other from American Orthopedic Foundation, during the conduct of the study; personal fees from Adventist Hinsdale Hospital, personal fees and non-financial support from Amplitude, grants, personal fees and non-financial support from Arthrex, personal fees and non-financial support from DJO Global, grants from Kaufman Foundation, grants, personal fees and non-financial support from Medacta, grants, personal fees, non-financial support and other from Pacira Pharmaceuticals, grants, personal fees, non-financial support and other from Stryker, grants from Breg, personal fees from Orthomerica, grants, personal fees, non-financial support and other from Mako Surgical Corp, grants and non-financial support from Medwest Associates, grants from ATI Physical Therapy, grants, personal fees and non-financial support from St. Alexius Medical Center, grants from Ossur, outside the submitted work; In addition, Dr. Domb has a patent 8920497 - Method and instrumentation for acetabular labrum reconstruction with royalties paid to Arthrex, a patent 8708941 - Adjustable multi-component hip orthosis with royalties paid to Orthomerica and DJO Global, and a patent 9737292 - Knotless suture anchors and methods of tissue repair with royalties paid to Arthrex and Dr. Domb is the Medical Director of Hip Preservation at St. Alexius Medical Center, a board member for the American Hip Institute Research Foundation, AANA Learning Center Committee, the Journal of Hip Preservation Surgery, the Journal of Arthroscopy; has HAD ownership interests in the American Hip Institute, Hinsdale Orthopedic Associates, Hinsdale Orthopedic

Imaging, SCD#3, North Shore Surgical Suites, and Munster Specialty Surgery Center.

Dr. Maldonado reports non-financial support from Arthrex, non-financial support from Stryker, non-financial support from Smith & Nephew, non-financial support from Ossur, outside the submitted work; and Dr. Maldonado is an editorial board member of the Journal of Arthroscopy.

VDr. Ortiz-Declet reports non-financial support from Abbvie, grants and non-financial support from Arthrex, non-financial support from Bioventus LLC, non-financial support from Ferring Pharmaceuticals, non-financial support from Horizon Pharma, non-financial support from Johnson and Johnson, non-financial support from Medacta USA, non-financial support from SeaPearl, non-financial support from Smith & Nephew, non-financial support from Stryker Corporation, non-financial support from Tornier, non-financial support from Vericel Corporation, non-financial support from Vertical Pharmaceuticals, outside the submitted work.

Dr. Chen reports grants, personal fees and non-financial support from Arthrex, non-financial support from Smith & Nephew, non-financial support from Ceterix, non-financial support from DePuy Synthes Sales, non-financial support from Desert Mountain Medical, non-financial support from Horizon Pharma, non-financial support from Medacta USA, non-financial support from Medtronic Xomed, non-financial support from Orthogenrx, non-financial support from Stryker, non-financial support from Tornier, grants from DJO Global, non-financial support from Gemini Mountain Medical, outside the submitted work.

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