Clinical Results of Meniscal Repair Related to the Arthroscopic Zone Subdivision

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Abstract

Methods: According to our clinical practice of arthroscopic meniscal suture repair, we subdivide the injured meniscus into four zones: zone I, the anterior horn; zone II, the anterior lateral part; zone III, the posterior lateral part; zone IV, the posterior horn. According to our method of arthroscopic zone-subdivision of the meniscus, the injured site of 26 menisci were zone I, 189 were zone II, 85 were zone III and 68 were zone IV. Three hundred and sixty-eight patients were followed-up by 48~60 months (average 52 months). The change of knee symptoms and function were observed and the functional score of the knee was evaluated.

Results: Three hundred and thirty-eight patients followed-up had no knee symptoms postoperatively. The arthroscopic zone-subdivision of meniscus where patients had clinical symptoms was as follows: 15 patients were at zone III, 5 patients were at zone II, 2 patients were at zone I, 3 patients were at zone IV. The mean Lysholm score was 50 ± 8 preoperatively and 93 ± 6 (t= -48.235, P=0.000) postoperatively at follow-up. There were significant therapeutic differences in the different arthroscopic zones (P<0.002).

Conclusions: Each arthroscopic zone-subdivision had its individual long-term clinical effects. The arthroscopic zone-subdivision of the meniscus was of certain significance to guide the arthroscopic suture of the meniscus.

Level of Evidence: Level IV, therapeutic case series.

INTRODUCTION

Arthroscopic meniscal repair has been proven to be an important way to treat meniscal tear by preservation of as much meniscus as possible [1]. For adolescents, preservation of maximal meniscal tissue is of great clinical significance to maintain joint stabilization, avoid recurrent tears, and prevent knee osteoarthritis [2,3]. In order to promote the technique of arthroscopic meniscal repair and improve the clinical effects, surgeons have sought various techniques including inside-out repairs, outside-in repairs and all-inside repairs [4]. However, the meniscal tears are not uniform, e.g., tears of different shapes, tears of different size, and tears in different zones. No single meniscal repair technique or device is superior in all situations of meniscal tears [5]. Surgeons have striven for appropriate and successful repair techniques for different types of meniscal tears. Yoon JR et al [6] presented a new technique designed for the reduction and repair of bucket-handle meniscal tears to achieve the assessment of its rotational component, the adequate revitalization of the tear margins and the proper reduction with maintenance of that reduction. Ahn JH et al [7] found that posterior lateral meniscus root tear (PLMRT) must be managed with different methods with tears of other areas because the tear configuration was more complex than it appeared. Choi NH et al [8] described a new arthroscopic technique to repair a tear of posterior root of the medial meniscus through a high posteromedial portal. Cho JH [9] recommended arthroscopic all-inside repair of anterior horn tears of the lateral meniscus using a spinal needle as an alternative technique. Wang KH [10] developed a new arthroscopic technique of direct repair for the radial tear of the PRMM (posterior root of medial meniscus) by using a posterior trans-septal portal. The thought was that the new technique could avoid disturbing the normal meniscal movement during flexion in a loaded condition. Choi NH et al [11] described the surgical technique and clinical outcomes after all-inside suture repair for radial tears of the mid body of the lateral meniscus. They drew a conclusion that meniscal repair for radial...
tears of the mid body of the lateral meniscus may be an effective alternative treatment to partial meniscectomy.

Our hypothesis is that if there are differences of surgical techniques at various zones of meniscal tears, we can choose the proper technique before or during the surgery according to the zone of injury. Thus we subdivided the meniscus into different zones and summarized the clinical results of arthroscopic sutures of meniscal tears at different zones.

METHODS

Three hundred and sixty-eight patients with meniscal tears were included in the study. Surgical treatment of all patients was performed with meniscal suture repair by a single surgeon. There were 278 male and 90 female patients whose mean age was 26 years (range, 16 ∼ 38 years). Two hundred and six cases were right knees and one hundred and sixty-two were left knees. Two hundred and twenty-five cases were lateral menisci and one hundred and forty-three cases were medial menisci. The “injury-to repair” intervals ranged from 6 weeks to 48 weeks, averaging 20 weeks. Of all the patients, 360 patients complained of knee pain especially after sports, 30 patients had limitation of knee ROM (locked sign), 355 patients had a positive McMurray test and 145 patients had a positive Apley test.

We evaluated the injured site of meniscus (anterior insertion of the meniscus, anterior part of the meniscus, posterior part of the meniscus or posterior insertion of the meniscus) preoperatively by any of the following conditions: (1) local tenderness to palpation along the joint line; (2) local introcession or a soft spot which can be touched with the examiner’s thumb; (3) increased movement of the meniscus when the knee was flexed or extended; (4) irritated pain accompanied by the movement of the knee. Preoperative MRI showed that 300 cases had Grade-3 signal intensity at meniscus [Supplemented Reference 1], 50 cases had signal deformation of meniscus and 18 cases had the sign of “double PCL” iebucket-handle tears.

According to our clinical practice of arthroscopic meniscal suture, we subdivided the injured meniscus into four zones by the arthroscopic appearance and differences in surgical techniques: zone I, the anterior horn; zone II, the anterior lateral part; zone III, the posterior lateral part; zone IV, the posterior horn. In the current study, 26 cases were at zone I, 189 cases were at zone II, 85 cases were at zone III, 68 cases were at zone IV (Figure 1).

The surgery was performed by the same surgeon. The medial and lateral menisci were probed in regular sequence through routine anteromedial and anterolateral portals. Besides being observed directly arthroscopically, injuries were also found by the following conditions during operation: (1) localized synovial hyperplasia and hyperemia; (2) coarse and lackluster meniscal surface or softness of local meniscus; (3) abnormal fold of the meniscus when the knee was moved; (4) denudation of local cartilage. The suture methods of all patients included inside-out with long suture needle of 218 patients, all inside suture by FasT-Fix of 92 patients and outside-in with hollow guiding cannula of 58 patients (Figure 2).

The patients followed up by 48 ∼ 60 months, averaging 52 months. Data of the patient complaint and knee function were collected during follow-up. The Student t test was used to compare preoperative and postoperative Lysholm knee score. The Mann-Whitney test was used to compare the clinical effect between any two zones by Lysholm scores [12]. Analysis was performed using SPSS 20.0 software and significance was assumed at $P<0.05$.

RESULTS

By follow-up, 356 patients had no symptoms; 10 patients complained of pain of knee after strenuous sports (2 at zone I, 3 at zone II, 15 at zone III, 1 at zone IV) 9 patients reported no improvement in symptoms (1 at zone I, 15 at zone III, 2 at zone IV) among which 4 patients received secondary arthroscopic meniscectomy (3 at zone III, 1 at zone IV). Thirteen patients had skin numbness at the distal area of incision and the numbness disappeared in two months. The arthroscopic zone-subdivision of meniscus at which patients had clinical symptoms was as follows: 15 patients were at zone III, 5 patients was at zone II, 2 patients were at zone I, 3 patients were at zone IV. The mean Lysholm score was 50 ± 8 preoperatively and 93 ± 6 ($t= -48.235$, $P=0.000,$) postoperatively at follow-up. There were significant
differences in the clinical effect of different zones $P<0.002$ by
the level of Lysholm scores [12] according to (Table 1).

**DISCUSSION**

Numerous meniscal repair techniques have been described,
but there remains no consensus among experts as to which is most
effective. Characteristics of meniscal tear must be considered
before choosing to repair a meniscus, including the location, size,
appearance, chronicity, and the presence of secondary tears [13].
We thought it important for improvement of the clinical results
in treatment of meniscal tear that a surgeon could identify the
injured area of meniscus in a short period of time during the
surgery. The following conditions of meniscal tears are usually the
cause of unsatisfactory results: tears at the edge of the synovium,
interlayer tears, multiple tears and bilateral tears [Supplemented
Reference 2]. So, the basic surgical techniques for arthroscopic
meniscal suture repair should include accurate identification of
meniscal tear before the operation as well as rapid location
of the injured part during the operation. We summarized the
clinical experience in arthroscopic meniscal sutures by a long
period of time and put forward the criteria for identification
of meniscal tears during physical examination of the patients
before the operation: (1) local tenderness to palpation along
the joint line; (2) local intro concession or a soft spot which can be
touched with an examiner's thumb; (3) increased movement of
the joint line; (2) local introcession or a soft spot which can be
touched with an examiner's thumb; (3) increased movement of
the joint line; (4) irritated pain accompanied by the movement of knee. Even though the MRI technique are popularized in clinical experiences, it can not be overemphasized for a surgeon to make more efforts in the basic physical examination of the knee joint in order to make
an accurate diagnosis of meniscal tear preoperatively. This skill,
besides the surgical technique, is key point in the improvement of
the results of meniscal suture.

Having a long experience of arthroscopic meniscal suture repair, we found that the arthroscopic techniques were somewhat different at different injured parts of meniscus. When surgeons began to learn the technique, they always felt that it was somewhat difficult to suture the meniscus or even hard to find the
injured parts of the meniscus in some specific cases. We therefore
summarized the clinical experience in arthroscopic meniscal
suture technique and subdivided the meniscus into different
zones according to its anatomic characteristics, arthroscopic
appearance and differences in arthroscopic operation technique.
Our criteria of zone - subdividing of meniscus is as follows: zone
I, anterior insertion of the meniscus; zone II, anterior part of
the meniscus; zone III, posterior part of the meniscus; zone IV,
posterior insertion of the meniscus. Zone of the meniscus is easy
to be observed under the arthroscope but difficult to be sutured
by inside-out technique. Outside-in technique of meniscal suture
may be needed to be adopted in I zone. Zone II of the meniscus is
not only the most easily observed under the arthroscope but also
easy to be sutured by inside-out technique. We suggested that the
new learners began to study and practice arthroscopic meniscal
suture technique from zone II of the meniscus. As the femoral
condyle acts as a visual obstacle in zone III, the injured parts of
zone III near the meniscocapsular junction are usually hard to
be observed directly under arthroscope. In the other hand, most
injured parts that failed to be found during the operation and led
up to unsatisfactory results of the treatment have meniscal tear
at zone III. Therefore if a patient was judged the meniscal tear
at zone III preoperatively, the surgeon should carefully explore
the meniscus with a probe whether there is a longitudinal tear
which cannot be seen under the arthroscope. There would be
a bucket-handle tear at zone III of the meniscus or a tear at the
meniscocapsular junction. A bucket-handle tear is easier to be
observed than simple longitudinal tears at the meniscocapsular
junction. For zone IV, posterior portals may be needed during
arthroscopic surgery in some patients. All inside technique may
be a choice to the suture of this zone.

In our study, Lysholm scores of the patients were $50 \pm 8$
preoperatively and $93 \pm 6$ postoperatively. The results of the
treatment were satisfactory. Among the nineteen patients who
had some complaint at following up, fourteen patients had
meniscal tear in subdividing zone III, 2 patients in zone I, 2
patients in zone IV and 1 patient in II zone. Therefore meniscal
tears in the subdividing zone III should be taken more attention
to during the operation. Meniscal tear at zone III of the medial
meniscus which was sheltered by the medial femoral condyle was
somewhat difficult to be observed under arthroscope. Surgeons
with more clinical experiences would be needed at this time.

From our clinical data collected over a long period of time and
the 368 cases followed up, the subdividing zones of meniscus not
only had differences in operation technique but in clinical results
of the surgical treatment. There were significant differences in
the clinical effect at different zones. The clinical results of the
patients with long term of following up showed that patients
who still had symptoms postoperatively were those who usually
had meniscal tears of zone III. We thought that the main reason
is because surgeons with less clinical experience were liable to
fail in finding the meniscal tear under arthroscope during the
operation. The other problems we met in the clinical experiences
included: the patients may have more than one injured parts
of meniscus; or arthroscopic technique of meniscal sutures at
zone III, because of the obstacle of the femoral condyle, was
more difficult than other zone of meniscus; both sides of injured
meniscus may not be contacted firmly by the sutures in zone III.
We usually used longitudinal suture technique combined with
transverse suture technique to repair meniscal tear at zone III.
The longitudinal suture technique could get together larger parts
of injured meniscus and transverse suture technique could make
both sides of injured meniscus contacted firmly by the sutures.
The clinical results proved that the technique had greatly improved the effects of meniscal suture.

<table>
<thead>
<tr>
<th>Zones</th>
<th>Excellent</th>
<th>Good</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone I ($n=26$)</td>
<td>22</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Zone II ($n=189$)</td>
<td>181</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Zone III ($n=85$)</td>
<td>63</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Zone IV ($n=68$)</td>
<td>60</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

$\chi^2$, $P$ value $\chi^2=32.158, P=0.000$
$Z$ value, $P$ value $Z_1=-11.35, P=0.000$
$Z_2=-4.215, P=0.002$
$Z_3=-8.018, P=0.000$
$Z_4=-12.036, P=0.000$
$Z_5=-4.215, P=0.002$

Zhu et al. (2016)
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Besides the surgical techniques, the postoperative rehabilitation program also played an important role in improvement of function of the knee after the meniscal sutures. The postoperative rehabilitation had such effects as (1) facilitating circulation of synovial fluid in order to promote the healing of sutured meniscus, (2) improving muscle strength to enhance joint stability, (3) avoiding cartilage degeneration with early step weight bearing, (4) preventing complications, e.g. stiff knee DVT (deep vein thrombosis), (5) improving the cardiovascular function and the psychological status of the patient. The other factors that may influence clinical results of meniscal suture included the patient’s age, injured time of meniscus, size of injured edge, extent of meniscal abrasion, joint stability and cartilage lesion, ACL or PCL rupture, etc. [13-15]. These factors should be evaluated before surgery. Otherwise the satisfactory clinical results would never be attained even though the excellent arthroscopic surgical techniques were performed.

LIMITATIONS

There are still some problems needed to be further investigated in our study. The concept of arthroscopic zone-subdivision could provide surgeons a scientific method to identify the torn meniscus during surgery and help them to perform the arthroscopic meniscal repair in a simple and fast way. But the reason that influenced the treatment results in different zones was only based on the clinical observation. Further experimental studies to explore the relationship and its mechanism between the results of arthroscopic meniscal suture and injured zones are needed.

CONCLUSIONS

Great importance of the menisci to knee biomechanics and function has been attached to and all kinds of suture techniques should be tried to preserve the meniscus. We observed the clinical results of meniscal suture at different zones and analyzed the influencing factors to provide a reference for the surgeons in arthroscopic suture of meniscal tears.

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REFERENCES

16. Supplemented References

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