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Cost-effectiveness of arthroscopic partial meniscectomy versus physical therapy for traumatic meniscal tears in patients aged under 45 years

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Aims

The aim of this study was to evaluate the cost-effectiveness of arthroscopic partial meniscectomy versus physical therapy plus optional delayed arthroscopic partial meniscectomy in young patients aged under 45 years with traumatic meniscal tears.

Methods

We conducted a multicentre, open-labelled, randomized controlled trial in patients aged 18 to 45 years, with a recent onset, traumatic, MRI-verified, isolated meniscal tear without knee osteoarthritis. Patients were randomized to arthroscopic partial meniscectomy or standardized physical therapy with an optional delayed arthroscopic partial meniscectomy after three months of follow-up. We performed a cost-utility analysis on the randomization groups to compare both treatments over a 24-month follow-up period. Cost utility was calculated as incremental costs per quality-adjusted life year (QALY) gained of arthroscopic partial meniscectomy compared to physical therapy. Calculations were performed from a healthcare system perspective and a societal perspective.

Results

A total of 100 patients were included: 49 were randomized to arthroscopic partial meniscectomy and 51 to physical therapy. In the physical therapy group, 21 patients (41%) received delayed arthroscopic partial meniscectomy during follow-up. Over 24 months, patients in the arthroscopic partial meniscectomy group had a mean 0.005 QALYs lower quality of life (95% confidence interval -0.13 to 0.14). The cost-utility ratio was €-160,000/QALY from the healthcare perspective and €-223,372/QALY from the societal perspective, indicating that arthroscopic partial meniscectomy incurs additional costs without any added health benefit.

Conclusion

Arthroscopic partial meniscectomy is arthroscopic partial meniscectomy is unlikely to be cost-effective in treating young patients with isolated traumatic meniscal tears compared to physical therapy as a primary health intervention. Arthroscopic partial meniscectomy leads to a similar quality of life, but higher costs, compared to physical therapy plus optional delayed arthroscopic partial meniscectomy.

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Introduction

Traumatic meniscal tears are a common knee injury in a young, active population. This type of meniscal tear usually occurs following sports-related trauma.[1] Traumatic meniscal tears limit patients in their activities during daily life and sports. As a consequence, this can lead to loss of quality of life (QoL).[2] Having a meniscal tear results in a six-fold increased risk of developing osteoarthritis (OA) of the knee joint, resulting in increased healthcare consumption.[3,4] Meniscal tears also have a significant impact at

Table I. Baseline characteristics.

Variable	Arthroscopic partial meniscectomy	Physical therapy
Patients, n	48*	51
Mean age at inclusion, yrs (SD)	34.1 (8.6)	35.6 (7.5)
Male sex, n (%)	37 (77.1)	38 (74.5)
Mean BMI, kg/m^2 (SD)	25.5 (4.2)	26.1 (4.6)
Mean TAS pre-injury (SD)	6.5 (2.2)	6.4 (2.0)
College education, n (%)	15 (31.2)	25 (49.0)
Paid work, n (%)	38 (79.2)	46 (90.2)
Mean EQ-5D-3L (SD)	0.741 (0.23)	0.733 (0.24)

*Of the 49 patients randomized to arthroscopic partial meniscectomy, one patient withdrew from the study.
EQ-5D-3L, EuroQol five-dimension three-level health questionnaire; SD, standard deviation; TAS, Tegner Activity Scale.

Table II. Mean costs and quality-adjusted life years per patient per treatment arm.

Variable	Arthroscopic partial meniscectomy	Physical therapy
Mean total healthcare costs, € (SD)	**3,645 (1,404)**	**2,881 (2,369)**
Mean hospital costs, € (SD)	**3,307 (1,335)**	**2,165 (1,724)**
Mean non-hospital costs, €	332	701
Social worker	3	5
General practitioner	23	40
Occupational medicine	17	13
Physical therapist and homeopathist	289	642
Pain medication, €	6	16
Total productivity costs, € (SD)	**6,036 (9,397)**	**5,778 (10,345)**
Absence paid work	3,100	2,290
Presenteeism paid work	2,498	2,839
Lost unpaid work	438	649
Total costs from societal perspective, €*	9681	8,659
Number of QALYs over two yrs (SD)	1.680 (0.36)	1.685 (0.33)

*Sum healthcare and productivity costs.
QALY, quality-adjusted life year; SD, standard deviation.

a societal level, e.g. reduced work productivity and increased work absence. Approximately 30,000 meniscectomies are performed annually in the Netherlands, of which half are on patients aged under 45 years.[5] These young patients are often in the midst of their working life, leading to an increased socio-economic burden.

Traumatic meniscal tears can be treated surgically, by an arthroscopic partial meniscectomy or meniscal repair, or non-surgically, by physical therapy with exercises.[6,7] Where patients opt for non-operative treatment with physical therapy, they may require surgery at a later time due to persistent knee symptoms. Arthroscopic meniscal surgical treatment carries some risk, though low, of serious complications, such as septic arthritis (0.135% to 0.211%), deep venous thromboembolism (0.413% to 0.568%), and pulmonary embolism (0.078% to 0.145%).[8,9]

Since resources in healthcare are scarce, there is a need to investigate the cost-effectiveness of treatment.[10] A cost-effectiveness analysis can determine which treatment results in the most health gain, and at what cost. So far, studies that have evaluated the costs of meniscal tear treatment only analyzed patients with a degenerative meniscal tear.[11,12] No previous study has investigated the cost-effectiveness of treatment of traumatic meniscal tears in young patients. In this study we compare arthroscopic partial meniscectomy with physical therapy with regard to costs and QoL. The aim of this study was to evaluate the cost-effectiveness of an arthroscopic partial meniscectomy versus physical therapy plus optional delayed arthroscopic partial meniscectomy in young patients with a traumatic meniscal tear, by using data from a recent randomized controlled trial (RCT) that compared both interventions.[13] In this RCT, early arthroscopic partial meniscectomy was not superior to a strategy of physical therapy with optional delayed arthroscopic partial meniscectomy at 24-month follow-up.

Methods

Study design and participants. This investigation was performed with data from the Study of Traumatic tears: Arthroscopic Resection vs Rehabilitation (STARR) trial, a multicentre open-labelled RCT for treatment of traumatic meniscal tears.[13] Patients were recruited between August 2014 and November 2018. We included patients aged 18 to 45 years with an isolated MRI-verified traumatic meniscal tear. Exclusion criteria were: a locked knee (i.e. when the patient was unable to fully extend or flex the injured knee, confirmed by clinical exam), a meniscal tear that was suitable for suture repair based on MRI findings,[14] a concurrent rupture of the anterior or posterior cruciate ligament, radiological signs of OA in the index knee (Kellgren-Lawrence grade 2 or higher),[15] disabling comorbidity, or insufficient command of the Dutch or English language. Full description of the study can be found in the clinical outcome study.[13] Ethical committee approval was sought and given, and all patients gave written informed consent. The

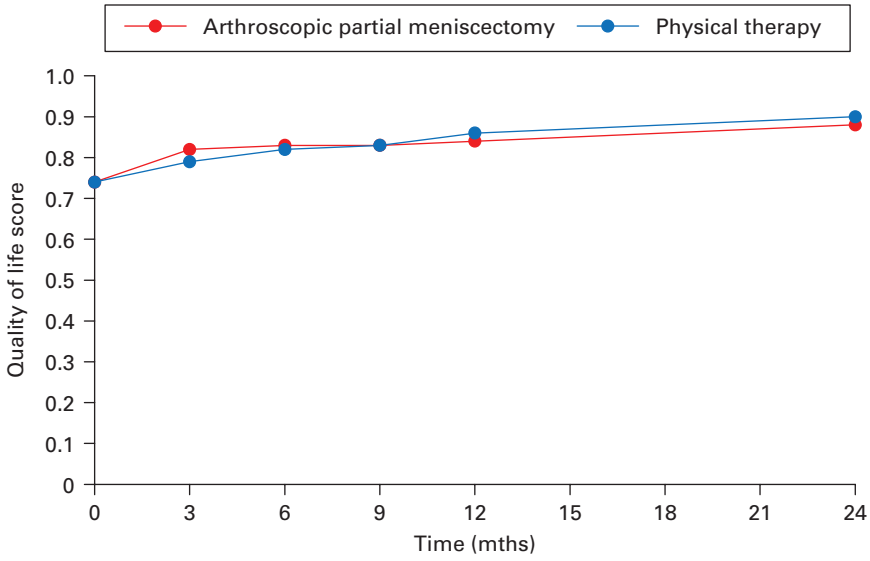

Fig. 1

Mean quality of life.

trial was registered at the Netherlands Trial Register with trial number NL4380 (NTR4511).

Patient involvement. Our patient panel consisted of three patients with traumatic meniscal tears. The trial protocol was discussed with a panel of patients with acute knee injuries before the protocol was submitted for ethical approval. In collaboration with these patients, we made our study protocol as similar as possible to standard clinical follow-up protocols used in everyday practice. Since 2010, we have expanded our use of patient participation panels on a regular basis. We plan to disseminate the study results to study participants.

Patients. Of the 100 patients included in the study, 49 were randomized to arthroscopic partial meniscectomy and 51 to physical therapy (Table I). Six patients (12%) of the arthroscopic partial meniscectomy group received no surgical treatment; knee complaints had resolved before surgery in four patients, one patient withdrew from the study, and one patient did not agree a date for surgery and could not be contacted. Four patients (8%) in the arthroscopic partial meniscectomy group had a meniscal repair instead of meniscectomy. A total of 21 patients (41%) in the physical therapy group underwent a delayed arthroscopic partial meniscectomy during the 24-month follow-up due to persistent knee complaints. Final follow-up was completed for 91% of all included patients. The cost and QoL data during follow-up had 10% missing values.

Interventions. Patients were randomized to either arthroscopic partial meniscectomy or physical therapy in a 1:1 ratio. Arthroscopic partial meniscectomy was performed within six weeks of inclusion. Postoperatively, patients were treated according to routine clinical practice and the Dutch national guidelines without standard referral to postoperative physical therapy.[16] Physical therapy consisted of a standardized exercise programme supervised by a physical therapist and home exercises (Supplementary Material). Delayed arthroscopic partial meniscectomy was allowed in the physical therapy group after at least three months of physical therapy, in case of persistent knee complaints and in consultation with the orthopaedic surgeon.

Outcomes. Data on QoL, healthcare costs, and productivity costs were collected through patient questionnaires at baseline and at three, six, nine, 12, and 24 months. We assessed QoL with the EuroQol five-dimension three-level health questionnaire (EQ-5D-3L), since the five-level EQ-5D was not available at the start of our study.[17] The EQ-5D-3L measures five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension consists of three levels: no problems, some problems, and extreme problems. The outcome score of the EQ-5D-3L is between 0 and 1, with 1 as best QoL and 0 as very poor and comparable to death. For each patient the number of quality-adjusted life years (QALYs) during the 24-month follow-up (taking into account all measurement moments) was calculated as an area under the curve (maximum is two QALYs per person over a period of two years). QALYs were calculated as follows as area under the curve: QALYs year 1=[(q0+ q3)/2+(q3+ q6)/2+(q6+ q9)/2+(q9+ q12)/2]/4. QALYs year 2 = (q12+ q24)/2. Total QALYS over two years = QALYs year 1+ QALYs year 2.

Healthcare costs included costs of hospital care, non-hospital care (such as physical therapy or general practitioner visits), and medication use related to pain. Use of healthcare was measured with the Medical Consumption Questionnaire at the above mentioned timepoints.[18] Healthcare costs were valued monetarily using diagnosis treatment combination tariffs, standard medication prices,[19] and updated reference prices from the Dutch Costing manual for economic evaluations in healthcare.[20]

Productivity costs included costs related to paid work (lost productivity at work (presenteeism) and absence from work (absenteeism)) and costs related to unpaid work (lost productivity or inability to perform unpaid work, such as household tasks). Productivity costs were measured with the Productivity

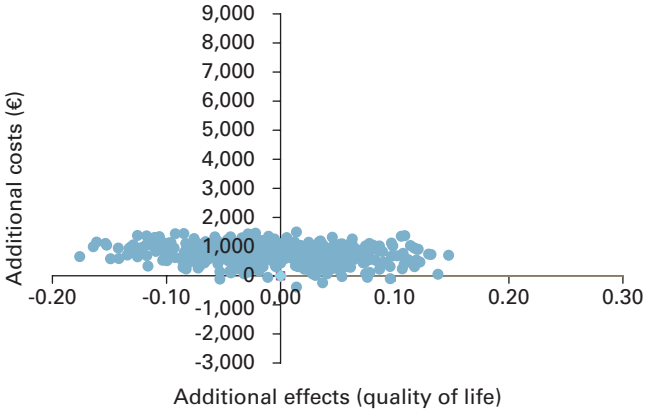

Fig. 2

Uncertainty analysis (healthcare perspective).

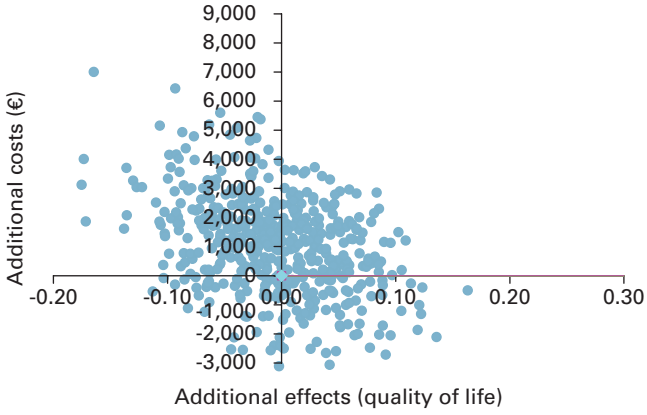

Fig. 3

Uncertainty analysis (societal perspective).

Costs Questionnaire and valued using the often-used, valid, friction cost method that limits long-term productivity costs, as unemployment permits replacement of ill workers after an adaptation period.[21,22]

A budget impact analysis was performed, to estimate the impact on the Dutch healthcare budget if the current practice of performing arthroscopic partial meniscectomy for treatment of traumatic meniscal tears would be replaced by physical therapy with optional delayed arthroscopic partial meniscectomy.

All costs were valued in € for the year 2018. For the second year, costs and health effects were discounted: costs by 4% and QALYs by 1.5%, conforming to the Dutch guidelines for economic evaluation in healthcare.[20]

Statistical analysis. We analyzed all patients according to their randomly assigned treatment (intention-to-treat). Over the period of 24 months, the difference in area under the curve of the QoL between groups was calculated to determine the number of QALYs gained or lost for arthroscopic partial meniscectomy compared to physical therapy. Cost-utility was calculated as incremental costs per QALY gained of arthroscopic partial meniscectomy compared to physical therapy. Calculations were performed from a healthcare system perspective (medical costs) and a societal perspective (medical and productivity costs). Missing values for costs and/or QoL were imputed based on linear interpolation in case the amount of missing values was less than 20%. Costs and QALYs were summed over the 24-month study period using the information of all follow-up moments. The uncertainty for costs and health effects was assessed by means of non-parametric bootstrapping, in which 5,000 observations were randomly drawn from the available study. The incremental costs and health effects for each bootstrap sample were displayed on a cost-effectiveness plane.

Results

QoL. Patients in the arthroscopic partial meniscectomy group had a total of 1.680 QALYs (standard deviation (SD) 0.36) during the two-year study period, compared to a total of 1.685 QALYs (SD 0.33) in the physical therapy group (between-group difference 0.005 (95% confidence interval (CI) -0.13 to 0.14)).

Figure 1 shows the QoL pattern over time for both treatment arms. QoL increased substantially over time and reached the level of the general population of the same age group at the end of the second year. Differences in QoL between the treatment arms were not clinically relevant or statistically significant.

Costs. The healthcare costs were €3,645 (SD 1,404) in the arthroscopic partial meniscectomy group and €2,881 (SD 2,369) in the physical therapy group (Table II). Hospital costs make up the majority of healthcare costs in both treatment arms. Within hospital costs, surgery costs dominate, especially in the arthroscopy arm but also in the physical therapy arm, as 41% of the patients randomized to physical therapy eventually underwent surgery during the follow-up period (n = 21).

Productivity costs were €6,037 (SD 9,397) in the arthroscopic partial meniscectomy group and €5,778 (SD 10,345) in the physical therapy group (Table II). Most productivity costs were related to paid work. Absence from work and lost productivity at work were not frequent, leading to a large variance in productivity costs between patients, which is often seen in studies of musculoskeletal disorders.[23-25]

Cost-utility. The results of the cost-utility analysis for both treatment strategies are presented in Table III. Using the healthcare and societal perspectives, performing arthroscopic partial meniscectomy instead of physical therapy for patients with traumatic meniscal tears incurs additional costs (€764 to €1,022) and leads to decrease in QALYs of 0.005. The incremental cost-effectiveness ratios shown in Table III are negative, and illustrate that arthroscopic partial meniscectomy is inferior to physical therapy for these patients.

The uncertainty analysis shows that using the healthcare perspective, arthroscopic partial meniscectomy led to a lower QoL in 53% of the bootstrap replications, and this treatment was more expensive in 95% of the replications (Figure 2). Applying the societal perspective, arthroscopic partial meniscectomy led to a lower QoL in 50% of the bootstrap replications and higher costs in 74% of the replications (Figure 3).

Budget impact analysis. About 30,000 arthroscopic partial meniscectomies are performed annually in the Netherlands.[5] Half of these are performed in patients aged under 45 years,

Table III. Cost-utility results of arthroscopic partial meniscectomy versus physical therapy. In this case, negative incremental cost-effectiveness ratios mean that performing an arthroscopic partial meniscectomy instead of physical therapy for these patients incurs additional costs, whereas no health benefit is produced.

Variable	Healthcare perspective	Societal perspective
Incremental cost, €	+764	+1,022
Incremental QALYs	-0.005	-0.005
Incremental cost per QALY, ICER in €	-160,000	-223,372

ICER, incremental cost-effectiveness ratio; QALY, quality-adjusted life year.

the target group of our study.[5] A more conservative treatment guideline could result in 40% fewer arthroscopic partial meniscectomies for this age group, resulting in 6,000 fewer surgeries per year. According to our study, these patients will get more physical therapy, about €340 per patient. The estimated annual budget impact of a more conservative guideline will be €19.2 million of savings in hospital costs and €2 million extra costs for physical therapy. On balance, about €17 million could be saved annually in the Netherlands without any expected health loss in terms of QALYs.

Discussion

Our cost-effectiveness analysis of arthroscopic partial meniscectomy compared to physical therapy plus optional delayed arthroscopic partial meniscectomy in young patients with a traumatic meniscal tear showed that arthroscopic partial meniscectomy resulted in similar QoL during 24 months but led to higher costs. This resulted in a cost-utility ratio of €-160,000/QALY from the healthcare perspective and €-223,372/QALY from the societal perspective. These negative cost-utility ratios indicate that performing an arthroscopic partial meniscectomy, instead of offering physical therapy plus optional delayed arthroscopic partial meniscectomy, for these patients incurs additional costs, without improved health benefit. Our budget impact analysis reveals that in the Netherlands, about €17 million could be saved annually if patients with traumatic meniscal tears are initially treated with physical therapy instead of arthroscopic partial meniscectomy. Study interpretation should consider that 41% of the patients who started with physical therapy underwent delayed arthroscopic partial meniscectomy during follow-up. Based on this study, arthroscopic partial meniscectomy is unlikely to be cost-effective compared to physical therapy plus optional delayed arthroscopic partial meniscectomy in the treatment of traumatic meniscal tears in patients aged under 45 years.

After 24 months, patients reached a QoL level of 0.88 in the arthroscopic partial meniscectomy group and 0.90 in the physical therapy group, comparable to the QoL in healthy people of the same age.[26] During the entire study period, we found a 0.005 QALYs (95% CI -0.13 to 0.14) lower QoL in the arthroscopic partial meniscectomy group compared to the physical therapy group. In the EQ-5D-3L questionnaire, 0.07 to 0.08 QALYs is considered to be the minimally important difference in QoL.[27,28] We can state that patients with a traumatic meniscal tear, treated with either arthroscopic partial meniscectomy or physical therapy, have no relevant or statistically significant difference in QoL during 24-month follow-up. This result is in line with the clinical outcomes in our previously reported results (the STARR trial), such as the International Knee Documentation Score,[29] which did not differ between treatment groups after 24-month follow-up.[13] From a clinical and health economics perspective, our results suggest that physical therapy is a reasonable alternative to early arthroscopic partial meniscectomy as first-line treatment in young patients with a traumatic meniscal tear.

The STARR trial is the first RCT comparing arthroscopic partial meniscectomy with physical therapy plus optional delayed arthroscopic partial meniscectomy in young patients with traumatic meniscal tears. Cost-utility analyses of these treatments in young patients with traumatic meniscal tears have not been done before. However, there are some cost-effectiveness studies on treating older patients with degenerative meniscal tears.[11,12] These studies showed that arthroscopic partial meniscectomy is not cost-effective as a first-line treatment in patients with degenerative meniscal tears. In this study we found comparable results, indicating that arthroscopic partial meniscectomy is unlikely to be cost-effective in treating patients aged under 45 years with traumatic meniscal tears.

Interpretation of this study, however, should consider that 41% of the patients started with physical therapy and then underwent arthroscopic partial meniscectomy during follow-up. In this study we only analyzed the patients as randomized treatment groups, which may not fully represent potential differences between patients who followed physical therapy only and those who underwent delayed arthroscopic partial meniscectomy after an initial period of physical therapy. Further studies should indicate whether QoL of patients who underwent delayed arthroscopic partial meniscectomy is comparable to patients who required physical therapy only. Costs for the physical therapy group only will probably decrease, and treatment quality could increase if we could predict which patients will need an arthroscopic partial meniscectomy, by reducing patients who receive both physical therapy and surgery.

Our study did not include the risk for OA for both treatments, since a follow-up period of 24 months is too short to assess this risk. It is known that patients who suffer meniscal tears have an increased risk for OA.[3] In the long term, differences between both treatment groups in the development of OA may influence healthcare costs, thereby influencing the cost-effectiveness.

Our study has several strengths. First, this is the first RCT investigating cost-effectiveness of arthroscopic partial meniscectomy in patients with a traumatic meniscal tear. Second, our trial's follow-up period of 24 months is relatively long for an empirical cost-utility analysis without long-term modelling. Third, we included the societal perspective in our analyses, like productivity loss and work absence, which other cost-effectiveness studies often do not include.

A limitation of our study is that we studied a relatively small population of 100 patients, compared to other cost-effectiveness studies. We also used the EQ-5D-3L, as the EQ-5D-5L had not been validated for economic evaluations at the start of our study.[30] We valued all costs in € for the year 2018. Updating the costs to 2021 would include multiplying all costs by factor 1.068 based on Statistics Netherlands, including costs of lost or gained QALYs.

In young patients aged under 45 years with isolated traumatic meniscal tears, arthroscopic partial meniscectomy leads to a similar QoL but higher costs compared to physical therapy plus optional delayed arthroscopic partial meniscectomy. Further analysis and investigation should consider that 41% of the patients who started physical therapy but subsequently required arthroscopic partial meniscectomy during follow-up. We conclude that arthroscopic partial meniscectomy is not likely to be the most cost-effective primary treatment of young patients with traumatic meniscal tears.

Take home message

- Arthroscopic partial meniscectomy leads to a similar quality of life but higher costs compared to physical therapy and is not likely to be cost-effective in the treatment of patients with traumatic meniscal tears aged under 45 years.
- Treating patients aged under 45 years with traumatic meniscal tears with initial physical therapy plus optional delayed arthroscopic partial meniscectomy leads to major health care savings, without any expected health loss in terms of quality-adjusted life years.

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Supplementary material

Physical therapy protocol and a description of the home exercises.

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Data sharing:
Individual de-identified participant data that underlie the results reported in this paper (text, tables, figures and appendices) and the study protocol will be shared if requested. Data will be available beginning 12 months and ending 5 years following publication of this paper. Data will be available for researchers who provide a methodologically sound scientific proposal, which has been approved by an ethical committee. Proof of the latter should be provided. Analyses should achieve the aims as reported in the approved proposal. Proposals for data should be directed to m.reijman@erasmusmc.nl.

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