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Original article

Visual analog scale assessment after medial patellofemoral ligament reconstruction: with or without tibial tubercle transfer

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Abstract

Background. We studied the efficacy of medial patellofemoral ligament (MPFL) reconstruction, with or without tibial tubercle (TT) transfer, for recurrent dislocation of the patella, based on subjective functional assessment using the visual analog scale (VAS).

Methods. Forty-two consecutive knees of 40 patients who underwent MPFL reconstruction using a hamstring tendon were followed up for an average of 4.3 years. Twenty-nine knees underwent MPFL reconstruction (MPFL group) and 13 knees underwent MPFL reconstruction combined with medial transfer of TT (TT+MPFL group). Clinical results, including the VAS score at the latest follow-up in both groups, were assessed.

Results. An apparent deficit in the range of motion was observed in two cases from the TT+MPFL group. The ratio of negative apprehension test was significantly improved from 3% preoperatively to 79% postoperatively in the MPFL group and from 8% to 69% in the TT+MPFL group. The Lysholm scores were significantly improved from 70 points preoperatively to 92 points postoperatively in the MPFL group and from 72 points to 90 points in the TT+MPFL group. There was no significant difference between the two groups in the ratios of negative apprehension tests and the Lysholm scores after surgery as well as before surgery. In the VAS assessment, the MPFL group scored significantly higher than the TT+MPFL group in "Japanese full sitting" (average score 92 vs 62). The scores of the two groups were not significantly different in any of the other items, although the total average score was significantly higher in the MPFL group (91 vs 81).

Conclusions. MPFL reconstruction without TT transfer achieved satisfactory results including high scores on subjective functional assessments without disadvantage caused by the TT transfer. Isolated MPFL reconstruction has been suggested to be a useful treatment method for recurrent dislocation of the patella.

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Introduction

Numerous procedures to treat recurrent dislocation of the patella have been described since the 1900s. The surgeries are classified into proximal realignment and distal realignment. Proximal realignment contains quadricepsplasty, medial patellofemoral ligament (MPFL) reconstruction, and lateral retinacular release (LRR), while medial transfer of the tibial tubercle (TT) typified by the Elmslie-Trillat procedure represents distal realignment. Triggered by the study conducted by Conlan et al.[1] in 1993, the important role of the MPFL in recurrent dislocation of the patella has been emphasized. Biomechanical evaluations have shown that the MPFL is the major medial ligamentous stabilizer of the patella. The restraining force against lateral patellar translation provided by the MPFL, expressed as a percentage of the total restraining force, has been estimated to be 53% in full extension,[1] 60% at 20° of knee flexion,[2] and 50% at 30° of knee flexion.[3] Nomura et al.[4] proved that isolated sectioning of the MPFL greatly increased the lateral shift of the patella during 20° to 90° of knee flexion and that MPFL reconstruction restored almost normal patellar tracking during 20° to 120° of knee flexion. Magnetic resonance imaging (MRI) studies on patellar dislocation have clarified the relationship between patellar dislocation and MPFL injuries.[5–7] Other studies have identified MPFL damage in knees with patellar dislocations, which suggests the important biomechanical function of MPFL against lateral dislocation of the patella.[8,9] MPFL deficiency is related to the feeling of instability identified by the apprehension test.[10] The authors confirmed a significant improvement in stability by an additionally performed reconstruction of the MPFL for patients with residual patellar instability after the medial transfer of TT.[11] We believe that MPFL reconstruction is the fundamental, effective, and anatomically reasonable procedure for recurrent dislocation of the patella.

Through the years of treating cases with recurrent patellar dislocations, our primary procedure has been gradually shifted from TT transfer to MPFL reconstruction. We have been performing MPFL reconstruction as a main surgery since 1997. During a transitional period between 1997 and 1998, we applied both TT transfer and MPFL reconstruction. Since 2001, we have rarely performed TT transfer even for patients with severe patellofemoral malalignment. Although we adopted different methods as our first choice procedures during different periods, the indication for the surgeries and the patient backgrounds for the MPFL reconstruction and TT transfer were basically the same.

We applied our original visual analog scale (VAS) to evaluate the knee function after surgery. The VAS is used as a measurement tool for subjective intensity for various emotion and sense. The intensity of feeling can be represented numerically and easily assessed by basic statistics by using the VAS system. In this study, we compared the clinical results of isolated MPFL reconstruction and MPFL reconstruction combined with TT transfer for recurrent dislocation of the patella. We hypothesized that the patients with isolated MPFL reconstruction achieved the same or better outcomes compared with the patients who received combined surgery of MPFL reconstruction and TT transfer. To examine this hypothesis, a subjective functional assessment using the VAS system was employed in this study. We believe that the VAS system will give us more detailed information than a conventional assessment and help to identify small differences between the two groups. By reviewing previously reported postoperative clinical outcomes for recurrent dislocation of the patella, we found only scarce detailed functional assessments for patients with patellar instability. As far as we are aware, no previous report has compared the clinical results of MPFL reconstruction and those of TT transfer in combination with MPFL reconstruction.

Patients and methods

Patients

We examined 42 consecutive knees in 40 patients with recurrent patellar dislocations who underwent MPFL reconstruction at a university hospital and two related institutions between 1993 and 2003 and were followed up after surgery for 18 months or longer. Knee specialists in each of the three hospitals performed the surgeries and followed up the patients. We tried to standardize the physical examination among our knee members based on the difference between the involved and uninvolved knees. Our cases included 12 knees of male subjects and 30 knees of female subjects. The subjects had an average age of 19 years (range 11–36 years) and the follow-up period averaged 4.3 years (range 1.5–8.1 years). Twenty-nine involved knees treated by MPFL reconstruction alone were defined as the MPFL group. The MPFL group contained 20 female subjects (69%) as the female MPFL group. Thirteen knees treated by TT transfer in combination with MPFL reconstruction in one or two stages were defined as the TT+MPFL group. The TT+MPFL group contained 10 female subjects (77%) as the female TT+MPFL group. In the TT+MPFL group, 8 knees were treated by TT transfer and MPFL reconstruction in a single stage (one-stage group), and 5 knees were treated by the procedures in two separate stages (two-stage group): an additional MPFL reconstruction was performed to the TT transfer in the second stage for persistent instability, not for pain. The backgrounds of the MPFL and TT+MPFL groups are shown in Table 1. This study was approved by the institutional review boards or alternative authorities in each hospital, and informed consent was obtained from each patient.

Table 1. Basic data on patients

Variable	MPFL (n = 29)	TT+MPFL (n = 13)
Age (years)[a]	19 (11–36)	20 (14–32)
Sex (male/female)	9/20	3/10
Time from injury to surgery (years)[a]	3.6 (0–19)	6.4 (1.3–16)
Number of preoperative patellar dislocations		
<3 times	11	2
>3 times	18	11
Preoperative Q angle	12.6 ± 4.8	12.9 ± 6.8
Follow-up period (years)*	4.3 (1.5–7.1)	4.4 (2.0–8.1)

MPFL, medial patellofemoral ligament; TT, tibial tubercle
[a]Average and data range in parentheses

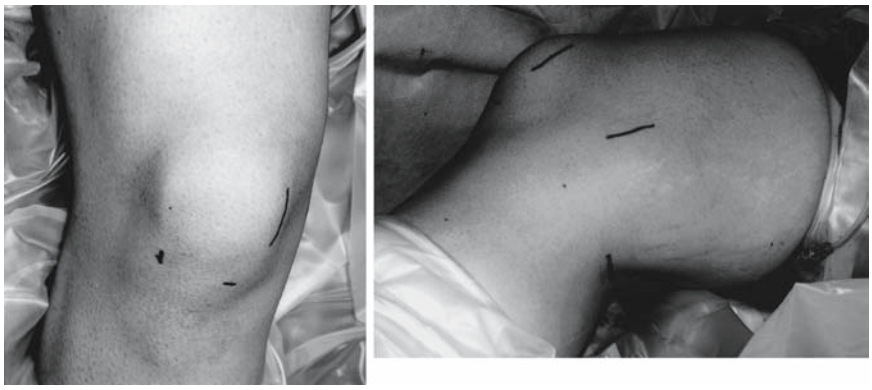

Fig. 1. Skin incisions for medial patellofemoral ligament (MPFL) reconstruction. **A** Anterior view of an operative right knee shows two 5-mm incisions for arthroscopy. **B** Medial view of the same knee shows a 3-cm incision on the medial popliteal region for harvesting the graft, and two 3-cm incisions on the medial epicondyle and medial edge of the patella for passing and fixing the graft

Surgical procedures of MPFL reconstruction and TT transfer

We commenced the MPFL reconstruction by arthroscopic examination to assess the inside of the knee joint. Arthroscopic procedures were applied when necessary. Next, we harvested the hamstring tendon via a transverse 3-cm incision on the anteromedial or posteromedial region of the knee (Fig. 1B). The semitendinosus or gracilis tendon was harvested for the reconstruction. Semitendinosus tendon was used as a double strand in 31 cases and as a single strand in 1 case, while gracilis tendon was used as a double strand tendon in 9 cases and as a single strand in 1 case. Although the length of the MPFL has been reported to be about 5.5 cm (range 4.5 to 7 cm),[12,13] the length measured during MPFL reconstruction was usually between 6 and 7 cm due to a small medial facet and lateral tilting of the patellar shape. Accordingly, we needed a graft of at least 16 cm for the cases treated with a double-strand graft. We made another two 3-cm incisions on the medial femoral epicondyle and medial margin of the patella, respectively (Fig. 1). The reconstruction route for the graft between the femur and patella was made between the MPFL and the synovial articular capsule[1,14] (Fig. 2). The graft length pattern was checked with the Isometric Positioner (Smith and Nephew, Andover, MA, USA) to obtain length change within 5 mm during a range of full extension to knee flexion of 120°. The femoral socket was positioned immediately distal to the adductor tubercle and superoposterior to the medial femoral epicondyle. The position was determined based on both anatomical and isometric criteria. The patellar side was fixed at the proximal one third of its medial margin. An EndoButton was used to fix the graft on the femoral side in most cases. On the patellar side, the graft was usually inserted beneath the prepatellar fascia and sutured against it with adequate tension in knee flexion of about 70°, where the patella was stabilized into the femoral groove.

Fig. 2. The reconstruction route was made by blunt dissection with a long pair of forceps from the paramedial incision to the medial epicondyle region between the second layer (original MPFL) and third layer (synovial capsule)

The TT transfer was performed by longitudinal osteotomy on the TT to move it medially an average distance of 12 mm with the fulcrum on the distal side. After the transferred tubercle was fixed temporarily with a Kirschner wire and confirmed for patellar tracking, it was fixed with two cortical bone screws.

When LRR was performed for the patients in the TT+MPFL group, the release progressed proximally at 1–2 cm from the lateral edge of the patella and extended to the distal attachment of the vastus lateralis muscle. When LRR was performed for the patients in the MPFL group, endoscopic release was employed. The LRR has been indicated for patients with lateral retinacular tightness or large patellar tilt. The indication for LRR has been gradually changed over the past decade and the procedure is now less frequently used than before. At present, the indication is determined by using a patellar tangential view with lateral tilt of 20° or more. The

contraindication for LRR is for patients with large medial mobility of the patella or a patellar tilt of less than 15°. In this study, LRR was applied to most of the cases in the TT+MPFL group (12 out of 13 knees), while it was done to a minority of the cases in the MPFL group (6 out of 29 knees). In all 42 subjects, the 18 knees that received LRR were defined as the LRR (+) group while the 24 knees that did not undergo LRR were defined as the LRR (–) group.

Postoperative management

The patients in both groups were encouraged to practice quadriceps setting and straight leg raising exercises to strengthen the muscle from the day following the surgery. Static partial weight bearing was also permitted as tolerated in knee extension with a simple knee brace. Range-of-motion exercise was initiated about 3 days after surgery. Walking with weight bearing on two crutches was also started and gradually progressed. When a patient obtained knee flexion of over 90°, he or she could be discharged and followed up in the outpatient section. Most of the patients could walk with full weight bearing in 2 to 4 weeks. The patients in the TT+MPFL group, however, were required to use braces or crutches when walking with full weight bearing until bone union was achieved. Patients in both groups who achieved sufficient range of motion, muscle strength, and stability were allowed to begin jogging at 3 months and to return to normal sports activities at 6 months.

Clinical evaluations

The following data were collected on each of the patients: range of motion and muscle strength of the knee, apprehension test of the patella, the Lysholm score, and functional assessment by VAS at the latest follow-up. Based on that information, the clinical outcome of the MPFL group was compared with that of the TT+MPFL group. The preoperative assessment was compared with the final assessment based on the results of the apprehension test and Lysholm score. The apprehension test of the patella was assessed as follows. If a patient experienced a moderate fear of dislocation when the patella was passively pushed laterally, the case was graded +. If a patient experienced severe fear of dislocation when the patella was passively pushed laterally and resisted performing the maneuver as a result, the case was graded 2+.

To examine the influence of additionally performed LRR, the Lysholm scores between the LRR (+) and LRR (–) groups were compared. The Lysholm scores between the female MPFL and female TT+MPFL groups were also compared, as were the one-stage and two-stage groups.

The isokinetic extensor strength and flexor muscle strength of the operated knee were measured using a Cybex II dynamometer (Cybex Division of Lumex, New York, USA), and the percentage of the contralateral knee at 60°/sec was evaluated.

Twenty-one items were assessed by VAS using a 100-mm-long scale. Patient perception was measured by having the patient mark the scale at any point up to the perfect score of 100. Pain, feeling of instability, and giving way were assessed in terms of both severity and frequency. Ambulation on flat ground was assessed in detail under three conditions: "walking," "running short steps," and "running very fast." Ambulation on stairs was assessed in detail under four conditions: "walking upstairs," "walking downstairs," "running upstairs," and "running downstairs."

Statistical analysis

Statistical comparisons were performed by the Student's *t*-test, Welsh test, and chi-square test applying Yates' correction for continuity. A probability (*P*) value of less than 0.05 was considered significant. The StatMate III statistical software package (ATMS, Tokyo, Japan) was used.

Results

Range of motion

No extension deficit of 5° or more was observed in range of knee motion in either group at the final evaluation. No flexion deficit of more than 5° was observed in the MPFL group. Flexion deficits of 10° or more were noted in two cases in the TT+MPFL group: one case treated by TT transfer and MPFL reconstruction in one stage, and the other case treated by the procedures in two stages.

Muscle strength

When the knee muscle strength was compared with that of the contralateral side at the latest evaluation, the operated knees had average muscle strength of over 85% in both extension and flexion. No significant difference was observed between the two groups with regard to muscle strength for extension and flexion of the knee. The MPFL group had an average muscle strength of 86% in extension and 93% in flexion. The TT+MPFL group had an average muscle strength of 87% in extension and 86% in flexion.

Table 2. Lysholm scores in both groups

	MPFL (n = 29)		Significance (P value)	TT+MPFL (n = 13)		Significance (P value)
	Preoperation	Postoperation		Preoperation	Postoperation	
Limp	4.6 ± 0.7	5.0	0.07	4.5 ± 0.9	5.0	0.08
Support	4.5 ± 1.0	5.0	0.05	5.0	5.0	—
Locking	14.2 ± 1.2	14.8 ± 0.9	0.35	13.3 ± 2.5	15	0.04
Instability	12.7 ± 4.9	23.2 ± 2.8	<0.001	13.8 ± 3.8	21.7 ± 5.8	<0.001
Pain	16.0 ± 6.0	20.7 ± 4.5	0.002	15.8 ± 6.7	20.0 ± 5.2	0.15
Swelling	6.8 ± 2.9	9.6 ± 1.7	<0.001	7.8 ± 2.7	9.7 ± 1.2	0.11
Stair climbing	7.2 ± 2.8	9.4 ± 1.4	<0.001	8.0 ± 2.1	9.0 ± 1.8	0.22
Squatting	4.2 ± 0.9	4.7 ± 0.5	0.16	4.2 ± 0.6	4.3 ± 0.6	0.89
Total	70.2 ± 16.7	92.4 ± 7.6	<0.001	72.4 ± 15.4	89.6 ± 11.1	0.005

Apprehension test

In the MPFL group, the ratio of cases graded negative on the apprehension test improved significantly from 3% (1 case) before surgery to 79% (21 cases) after surgery ($P < 0.001$). In the TT+MPFL group, the ratio improved significantly from 8% (1 case) before surgery to 69% (9 cases) after surgery ($P = 0.005$). There were no significant differences between the two groups in the preoperative and postoperative ratios of cases graded negative in the apprehension tests. In the MPFL group, the ratio of cases graded 2+ decreased significantly from 31% (9 cases) before surgery to 0% after surgery ($P = 0.004$). In the TT+MPFL group, the ratio decreased without statistical significance from 46% (6 cases) before surgery to 8% (1 case) after surgery ($P = 0.077$). There were no significant difference between the two groups in the preoperative and postoperative ratios of cases graded 2+.

Lysholm score

There were no significant differences between the two groups in the overall Lysholm scores or in the Lysholm scores for any single item, either before or after the surgery (Table 2). The overall Lysholm score in the MPFL group improved significantly from 70 points before surgery to 92 points after surgery ($P < 0.001$). The overall Lysholm score in the TT+MPFL group improved significantly from 72 points before surgery to 90 points after surgery ($P = 0.005$).

Regarding the effects of LRR, there were no significant differences between the LRR (+) and LRR (−) groups in the preoperative and postoperative overall Lysholm scores. The Lysholm score in the LRR (+) group improved significantly from 70 points before surgery to 91 points after surgery ($P < 0.001$). The Lysholm score in the LRR (−) group improved significantly from 71 points before surgery to 92 points after surgery ($P < 0.001$).

Concerning gender distinction, there was no significant difference between the female MPFL and the female TT+MPFL groups in the preoperative and postoperative overall Lysholm scores. The Lysholm score in the female MPFL group significantly improved from 70 points before surgery to 92 points after surgery ($P < 0.001$). The Lysholm score in the female TT+MPFL group significantly improved from 70 points before surgery to 89 points after surgery ($P = 0.009$).

Respecting the stage of surgery in the TT+MPFL group, there was no significant difference between the one-stage and two-stage groups in the overall Lysholm scores before and after surgery. The Lysholm score of the one-stage group improved, without statistical significance, from 74 points before surgery to 87 points after surgery ($P = 0.11$), while that of the two-stage group improved significantly from 69 points before surgery to 95 points after surgery ($P = 0.009$).

Detailed assessment with visual analog scale

Both groups scored 100 points in "walking on flat ground." The lowest-scoring item on average in the MPFL group was "sports ability," but this score was still as high as 84 points. The lowest-scoring item on average in the TT+MPFL group was "Japanese full sitting," with a score of 62 points. The MPFL group scored significantly higher than the TT+MPFL group in "Japanese full sitting" (average score: 92 vs 62, $P = 0.047$). The MPFL group tended to score higher on average than the TT+MPFL group for the other items, but none of the differences was significant. The average total score for all items was significantly higher in the MPFL group than that in the TT+MPFL group (91 vs 81, $P < 0.001$) (Table 3).

Discussion

The backgrounds of the MPFL and TT+MPFL group were not exactly the same in this retrospective study.

Table 3. Average scores of visual analog scale at the latest evaluation in both groups

	MPFL (n = 29)	TT+MPFL (n = 13)
Satisfaction with the operation	87 ± 18	73 ± 29
Total function of the knee	89 ± 13	84 ± 17
Satisfaction with the knee	89 ± 19	75 ± 26
Sports ability	84 ± 18	69 ± 31
Pain		
Severity	85 ± 20	86 ± 14
Frequency	88 ± 16	87 ± 14
Feeling of instability		
Severity	89 ± 19	77 ± 30
Frequency	91 ± 15	77 ± 31
Giving way		
Severity	93 ± 14	81 ± 29
Frequency	95 ± 12	80 ± 32
Walking on flat ground	100	100
Running short steps	96 ± 10	88 ± 31
Running very fast	88 ± 22	84 ± 30
Walking upstairs	96 ± 9	90 ± 25
Walking downstairs	96 ± 10	90 ± 25
Running upstairs	92 ± 16	85 ± 32
Running downstairs	96 ± 10	79 ± 37
Pivoting	85 ± 25	84 ± 31
Hopping on one foot	86 ± 26	81 ± 31
Squatting	93 ± 20	77 ± 37
Japanese full sitting*	90 ± 25	62 ± 38
Total**	91 ± 17	81 ± 28

*Statistically higher score in MPFL group than in TT+MPFL group (P = 0.047); **Statistically higher score in MPFL group than in TT+MPFL group ($P < 0.001$)

However, the age, sex, time from injury to surgery, number of preoperative patellar dislocation episodes, preoperative quadriceps angle (Q angle), and follow-up period did not significantly differ between the two groups. Based on the similarity of patients' data in both groups, the clinical results of them were compared.

We have to consider the influence of the LRR on the MPFL and TT+MPFL groups. The LRR might effectively work with MPFL reconstruction as well as TT transfer, but it could increase the instability of the patella ending up with worse clinical results in some cases. The comparison of the Lysholm scores between the LRR (+) and LRR (−) groups, however, showed that the release did not have considerable influence on the results.

Given that women generally have more joint laxity than men, it would be possible for this type of joint stabilization surgery to achieve worse clinical results in female patients. In this study, however, the female ratio in the MPFL group and the TT+MPFL group did not differ significantly. The Lysholm scores of the female groups demonstrated that the results did not differ significantly with the entire groups. Therefore, the dispersion due to sex differences was not considered to affect the results in this series.

The TT+MPFL group consisted of the one-stage and two-stage groups as described in the methods. The Lysholm scores of both groups did not differ significantly either before or after surgery. The scores of both groups improved, although the two-stage group had better improvement. Each group had one case with a flexion deficit of 10° or more. Although we were afraid that the repeat surgery in the two-stage group would give adverse effects on the involved knees, no undesirable influence could be found in this study.

There were two cases in the TT+MPFL group with an apparent range-of-motion deficit. Given the small number of cases included in the study overall, no significant difference could be revealed when Yates' correction was applied to the chi-square test. However, 15% (2 out of 13 knees) in the TT+MPFL group left significant flexion limitation, whereas no patients had this kind of complication in the MPFL group.

Among the reported various scales for assessing knee function, we tried to apply the VAS system to assess the delicate feelings and difficulties of patients with recurrent dislocations of the patella in this study. The Kujala scale, a well-known assessment, evaluates the subjective symptoms and functional limitations in patellofemoral disorders based on a rating of 13 items.[15] Each item is ranked in three to five grades and is assigned points according to the grade. The maximum total score is 100 and a high score indicates greater stability. The VAS scale can provide a more subjective and detailed functional assessment than the Kujala scale. Flandry et al.[16] compared subjective knee analysis using VAS with three subjective evaluation methods, that is, the Lysholm scale, the Noyes knee scale, and the Larson scale. They proved that VAS possessed greater sensitivity, greater statistical power, and high patient compliance. To eliminate apprehension of patellar instability and regain functional stability operatively are the most important and fundamental requirements for patients with recurrent dislocations of the patella. The VAS is a sensitive measure of not only instability and pain of the knee, but also daily activities and sports activities of patients. "Japanese full sitting" was the only item to score significantly lower in the TT+MPFL group in the VAS assessment. Although it is difficult to specify the reason, the range-of-motion deficit as well as kneeling pain due to the transferred tibial tubercle could obstruct "Japanese full sitting" in the TT+MPFL group.

To our knowledge, there is no report comparing MPFL reconstruction and TT transfer in respect to postoperative osteoarthritis. The TT transfer, however, is associated with excessive stress loaded onto the medial femorotibial joint, which may accelerate the progress of medial osteoarthritis.[17] A change of patellar tracking or

stress on the patellofemoral joint may also contribute to osteoarthritis in the patellofemoral joint.[18]

Mikashima et al.[10] reported that isolated MPFL reconstruction was more useful than isolated TT transfer, based on a comparison of clinical outcomes of an MPFL group and a TT group. At the final assessment of the study, the results of an apprehension test and the stability examined by radiograph were significantly better in the MPFL group than in the TT group.

In the current study, both of the MPFL and TT+MPFL groups obtained adequate improvement in the apprehension test, Lysholm score, and muscle strength. The MPFL group also obtained superior or at least comparable results in the range of motion and subjective functional assessment using the VAS system. In other words, MPFL reconstruction without TT transfer achieved satisfactory results without imposing the disadvantages associated with TT transfer. We believe that this study partially confirms our hypothesis. Further investigations, including randomized control studies, will be required to definitively confirm the hypothesis.

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