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Gait Analysis in Primary Total Knee Arthroplasty with and without Patellar Resurfacing: A Randomized Control Study

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Abstract: It is still controversial whether or not to resurface patella during primary total knee arthroplasty (TKA). One of the reasons may be insensitive measurement tools. We conducted a randomized controlled study to compare kinematic and kinetic parameters of resurfacing and nonresurfacing patella with the Vicon gait analysis system. The results show that patient post-operative gait of the two groups improved compared to pre-operative gait. Part of gait parameters, knee flexion at heel-strike, double limb support time and maximum adduction angle appeared to be statistically difference in 3 months, but 12 months later, the gait parameters of the two groups had no significant difference. Therefore, it seems that the final function of knee after TKA is not related whether or not to resurface patella.

Key words: total knee arthroplasty (TKA), patellar resurfacing, kinematics and kinetics, Vicon gait analysis system
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1 Introduction

Total knee arthroplasty (TKA) is a well-established procedure, and has proven to be durable and effective to treat advanced arthritis of the knee joint. Early TKA did not include patellar replacement and was only carried out when anterior knee pain was reported. Ever since patella resurfacing was introduced, research and discussion on resurfacing patella were increasing. Recent meta-analysis or evidence-based analysis has reached a consensus[1-4], although there is a tendency to resurface the patella in patients with inflammatory arthritis[5], whether the patella should be resurfaced for the primary TKA is still controversial for the time being.

Advocates for leaving the patella surfaced and proponents of routine patella resurfacing have their studies supported respectively. Advocates for leaving the patella resurfaced think that resurfacing patella brings new complications. Those complications include component failure, avascular necrosis[4], instability, fracture, tendon rupture and soft tissue impingement[6]. Proponents of routine patella resurfacing insist that patella resurfacing is effective manipulation to reduce the incidence of anterior knee pain[7].

Even if their studies are randomized and controlled, results of those studies are still contradictory. One reason is that different research conclusions result from different sample sizes, implant designs[8], surgical techniques and evaluation methods. Another reason may be insensitive assessment tools of knee function, such as questionnaires. If more objective assessment tools are used, impalpable differences between resurfacing and nonresurfacing might be found. In a recent study, Hemert *et al*[5] used the Dynaport knee test and the Minimod gait test to assess the function of the knee after TKA. The Dynaport knee test showed a significant functional advantage for patients with a resurfaced patella, while knee society score (KSS) did not.

The gait analysis system was put into use to assess the function of knee after TKA in the 1970s[9], but few papers used it to compare patella resurfacing and nonresurfacing. We conducted a randomized controlled study to compare gait analysis parameters of resurfacing and nonresurfacing patella with the Vicon gait analysis system. We tried to find better surgical techniques for knee function after TKA by using a more objective assessment tool.

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2 Materials and Methods

2.1 Subjects

52 patients with unilateral osteoarthritis were selected in the study and treated by TKA between 2006 and 2007. Patients were randomly (computer-generated random number) divided into a resurfaced group (n=27) and a nonresurfaced group (n=25). The resurfaced group contains a mean of 67 years old (53—78 years), 10 males, 17 females, 11 left knees and 16 right knees. The nonresurfaced group contains a mean of 66 years old (55—74 years), 11 males, 14 females, 10 left knees and 15 right knees. Meanwhile, twenty healthy individuals were recruited whose age, height and weight matched each patient. The body mass index (BMI) and statistical difference (P) were recorded. The mean and standard deviation (SD) of patient characteristics of resurfacing and nonresurfacing patella are shown in Table 1. The standard of diagnosis was based on the Society of American College of Rheumatology.

Table 1 Patient characteristics of resurfacing and nonresurfacing patella

	Patella resurfacing		Patella nonresurfacing		P
	Mean	SD	Mean	SD	
Age/years	67.00	7.94	66.00	6.11	0.756 0
Height/cm	164.17	6.56	166.80	5.35	0.321 3
Weight/kg	63.92	10.76	60.70	11.26	0.501 9
BMI/(kg·m^{-2})	23.62	3.02	21.66	2.86	0.136 2

2.2 Operation Technique and Rehabilitation

All operations (resurfacing and nonresurfacing patella) were conducted by an experienced surgeon. Anterior and posterior cruciate ligaments were resected in all patients. The implant prothesis in TKA was NexGen LPS-Flex (Zimmer Inc., US). Femur, tibia and patella prothesis were routinely fixed by bone cement. CBC II blood conversion system (Stryker, US) was used after the operation. Rehabilitation by the same therapist group followed the operation: knees exercise by continuous passive motion (CPM) 24 hours later, starting from 0°—60° and increasing daily; patients exercise and walk with a walker after 5—6 days; length of stay in hospital is 9—21 days (mean of 16 days). Training directions were continuously given by phone calls after their hospital leave.

All patients were asked to come back for a check every month for the first three months and every two months after the first three months. The complication of prosthesis loosening and dislocating did not happen in any patients. One case (4%) in the nonresurfacing patella group had anterior knee pain (treated by painkiller). One case following up was failed in resurfacing patella group because of moving 26 patients remained in the group.

2.3 Gait Analysis Test

All patients were clinically assessed using gait analysis equipment in preoperative, three-month and twelve-month post-operation (time discrepancy exists depending on the follow-up). A Vicon 6.12 motion analysis system (Oxford Metrics Ltd., Oxford, UK) with six infrared cameras (120 Hz interlaced) was used to capture three-dimensional kinematic and kinetic data. The distance of the walkway was 10 m and there were two Kistler 9286 force-platforms (Kistler Instruments, Winterthur, Switzerland) in the center of the walkway. The base parameters of patients were recorded before the gait test, which included name, gender, height, weight and length of the lower limb. The sixteen markers were pasted to the bilateralis base of the sacrum, anterior superior iliac spine, 15 cm up to the condylus lateralis femoris, condylus lateralis femoris, 15 cm up to the lateral malleolus, lateral malleolus, calcaneal tuberosity and second caput ossis metatarsalis respectively. Then level walking was ordered. It was regarded as a successful record that the left and right foot all contacted the force-platform once. The walk data were transferred into a computer and analyzed by the software (Polygon 1.4) automatically. All of kinematics and kinesics parameters are presented in Table 2.

2.4 Statistical Analysis

It has been generally accepted that the subject age, gender, height and weight can all affect the results of gait analysis[10-12]. T-test was carried out in the patient characteristics between two groups. In order to determine which surgical techniques were more advantageous to knee function after TKA, an analysis of variance (ANOVA) test was used to test the difference of pre, post three months and post 1 year in kinematics and kinetics. All analyses were done using the statistical analysis system (SAS) 8.0 statistical program (SAS Institute Inc., Cary, NC, USA). A value of statistical

Table 2 Kinematics and kinetics parameters

		Mean (SD)						
		Patella resurfacing ($n = 26$)			Patella nonresurfacing ($n = 25$)			Healthy
		Pre-operation	3 months	12 months	Pre-operation	3 months	12 months	
Stride length/m		0.90(0.21)	1.08(0.16)	1.08(0.14)	0.88(0.17)	1.03(0.12)	1.05(0.13)	1.14(0.12)
Velocity/($m \cdot s^{-1}$)		0.52(0.10)	0.92(0.08)*	0.91(0.11)*	0.56(0.10)	0.89(0.12)*	0.86(0.13)*	1.01(0.14)
Cadence		86.97(15.85)	99.46(8.36)	99.60(7.66)	86.52(14.49)	94.17(10.19)	94.68(9.39)	101(11)
Single limb support time (affected knee)/s		0.42(0.05)	0.50(0.08)	0.49(0.08)	0.42(0.05)	0.48(0.06)	0.48(0.05)	0.52(0.04)
Flexion angle at heel-strike/(°)		15(3.42)	8(4.21)*	7(5.11)*	16.26(4.14)	10(3.56)*&	7(5.65)*	7(2.5)
Double limb support time/s		0.34(0.08)	0.42(0.10)*	0.42 (0.10)*	0.34(0.05)	0.47(0.02)*&	0.46(0.02)*	0.49(0.03)
Maximum flexion angle during stance/(°)		11.50(5.01)	21.07(8.21)*	20.50(6.06)*	12.00(4.98)	20.83(3.19)*	21.67(4.59)*	22.05(3.11)
Maximum flexion angle during swing/(°)		36.01(16.52)	48.00(15.90)	48.83(15.93)	37.17(16.04)	45.83(12.69)	44.17(11.02)	49.21(10.33)
Maximum adduction angle/(°)		5.50(4.59)	2.33(2.07)	2.50(2.17)	8.50(4.32)	2.67(2.16)*&	2.50(2.07)*	2.34(1.28)
Maximum abduction angle/(°)		28.83(14.91)	27.17(11.60)	27.16(10.72)	30.83(13.54)	26.67(9.48)	27.67(9.29)	25.41(8.64)
Maximum round reaction force affected limb (% of body weight)		1.11(0.05)	1.03(0.04)*	1.05(0.04)*	1.11(0.05)	1.03(0.02)*	1.02(0.02)*	1.13(0.11)
Maximum flexion moment/($N \cdot m$)	Health knee	0.35(0.33)	0.15(0.06)	0.14(0.06)	0.20(0.06)	0.15(0.05)	0.15(0.05)	0.39(0.10)
	Affected knee	0.23(0.11)	0.25(0.09)	0.24(0.08)	0.22(0.07)	0.15(0.02)	0.21(0.05)	—
Maximum extension moment/($N \cdot m$)	Health knee	0.27(0.03)	0.52(0.08)*	0.53(0.11)*	0.32(0.06)	0.67(0.12)*	0.54(0.10)*	0.73(0.42)
	Affected knee	0.43(0.12)	0.74(0.39)	0.73(0.39)	0.45(0.10)	0.63(0.23)	0.51(0.07)	—

difference $P < 0.05$ was considered to be significantly different.

3 Result

There is no significant difference in age, weight, height and BMI between the patella resurfacing and nonresurfacing group. The result of gait analysis showed that the patient's post-operation gait improved in two groups compared with pre-operation (* marked in the Table 2, $P < 0.01$), but still did not reach normal after 12 months. Three months later, a post-operation statistical difference was found in the gait parameters of the knee flexion at heel-strike, double limb support time and maximum adduction angle between two groups ($^{\&}$ marked in the Table 2), but all kinematic and kinetic parameters were not statistical difference in post-operation 12 months later($P > 0.05$).

4 Discussion

In the study, we contrasted kinematic and kinetic parameters of patella surfacing and nonsurfacing for the purpose of evaluating knees post-TKA to find which surgical technique was better for knee function after TKA. The results showed that patient post-operative gait of the two groups clearly improved compared to pre-operation, and the gait of the nonresurfacing patella group was closer to normal in short-term (3 months) than that of the surfacing group, but 12 months later, the gait parameters of two groups had no significant difference.

Whether to resect cruciate ligament, unilateral TKA and bilateral TKA or not might affect the gaits of the patients[13]. Therefore, in order to increase accuracy, all patients received unilateral TKA and anterior and posterior cruciate ligament were resected in the operation. In the study, the patients were randomly distributed to the patella resurfacing group and the nonresurfacing group, with no statistical difference in age, weight, height and BMI.

In recent years, studies using gait analysis to follow up TKA increased. The gait analysis system can investigate several joints kinematics and biomechanics at the same time, which is convenient for improving or comparing implant design, evaluating muscle and force[14], even predicting post-operation joint function[15]. According to our literature review, less studies on patella surfacing used gait analysis systems. Pollo *et al*[16] conducted a patellar resurfacing versus nonresurfacing study with a 5-camera motion analysis system and a force platform (AMTI OR6-5, AMTI Inc., MA, USA). Walking, chair rising and stair climbing after TKA were analyzed. The result of this study indicated that gaits have no significant difference between patients after TKA with and without a resurfaced patella. In 2006, Smith's study[17] of patella resurfacing using Vicon 370 motion analysis system found that with the Profix design, no gait parameter displayed a difference near statistical significance between TKA with and without patellar resurfacing except for the knee flexion at heel-strike. Similar results occurred in our study, however, double limb support time and maximum adduction angle appeared to be statistically different in the third month. It likely resulted from different implant design and patient characteristics.

The knee after TKA would adapt itself in a new walk situation. The adaptability makes it more natural and convenient. It seems that the reason of difference in 3 months but no difference in 12 months is that the knee adapts itself continuously with increasing walk.

Almost all studies showed that the knee after TKA could not go back to the normal. From our perspective, the function of the affected knee could not go back to normal regardless of the resurface of the patella, which was called a biphasic sagittal knee moment pattern[13]. The pattern is relevant to the operation of TKA, not to the resurfacing patella.

The main argument in patella resurfacing is complication after TKA. Advocates for leaving the patella surfaced insist that new complications might occur in the patient with patella resurfacing[4], while proponents of routine patella resurfacing insist that patella resurfacing is an effective manipulation to reduce the incidence of anterior knee pain[7]. But Barrack *et al*[18] supposed that the postoperative anterior knee pain is related either to the component design or to the details of the surgical technique, rather than whether or not the patella is resurfaced. In the study, only one anterior knee pain (4%) in the patella nonresurfacing group and no complications in the patella resurfacing group is not sufficient to make a conclusion that the resurfacing patella is more advantageous than the nonresurfacing patella.

In our study, all kinematic and kinetic parameters have no significant difference in 1 year. The follow-up time is short. Though, unknown problems such as complications and re-operation are out of reach, some long-term follow-up studies also do not find a significant different between resurfacing and nonresurfacing patella. From Burnett's prospective, randomized, double-blind study, which had at least 10 years of follow-up, there was no significant difference in the range of motion, knee society clinical rating score, satisfaction, revision rates, and anterior knee pain comparing patella resurfacing and nonresurfacing[19]. Campbell's 10 year follow-up study showed that there was no significant difference in the deterioration of scores with time and

further patellafemoral complications between the two treatment groups. Other above 10 year follow-up studies had similar results to those of Refs. [20-21].

5 Conclusion

The study result indicated that the gait was different in short-term (3 months) between the two groups, but not in long-term (12 months). It seems that if no serious complication occurs after primary TKA the final function of knee is not related whether or not patella is resurfaced.

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