Comparison of range of motion after standard and high-flexion posterior stabilised total knee replacement

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Abstract The purpose of this study was to compare the range of motion after standard version posterior stabilised TKR and high-flexion version TKR in patients receiving bilateral total knee replacement. Thirty-five patients were recruited. The range of motion of the knees was measured clinically with a goniometer in both the pre-operative period and the most recent follow-up. It was found that the pre-operative range of motion was comparable in the two groups. The average post-operative flexion was $105^{\circ} \pm 13^{\circ}$ in the standard version group and $106^{\circ} \pm 14^{\circ}$ in the high-flexion design group ($p=0.201$, paired t-test; beta error=0.073). A slight loss in flexion was observed in the standard version group (0.5°) as opposed to a slight gain in the high-flexion design group (2°). However, this was not statistically significant ($p=0.251$, paired t-test; beta error=0.105).

Résumé Le but de cette étude est de comparer la mobilité du genou après prothèse totale postéro stabilisée et prothèse total type « high-flexion », tous les patients étant opérés des deux genoux dans le même temps opératoire. 35 patients ont été inclus, la mobilité des genoux a été mesurée cliniquement en pré-opératoire et au plus grand recul. La mobilité pré-opératoire a été comparable dans les deux groupes, la mobilité post opératoire a été de $105^{\circ} \pm 13^{\circ}$ dans la prothèse standard contre $106^{\circ} \pm 14^{\circ}$ dans les prothèses

dites « high-flexion » ($p=0.201$). Une petite perte de flexion est observée dans le groupe standard (0.5°), le gain dans le groupe des prothèses dites « high-flexion » est modéré (2°). Il n'y a pas de différences significatives entre ces deux groupes ($p=0.251$).

Introduction

Range of motion is an important outcome measure of the success of total knee arthroplasty. Achieving deep knee flexion is especially important in some parts of the world for cultural or religious reasons. There are many factors governing the flexion range of the knee after total knee arthroplasty [4, 8, 9, 12]. The design of the prosthesis is one of these. On the market there are designs which have been modified from previous versions to allow for deep flexion of the knee to occur safely [1, 2]. However, the clinical results are controversial [3, 5, 6, 10]. The purpose of this study is to investigate whether there is any difference in terms of maximum knee flexion in patients receiving standard version total knee replacement in one knee (Zimmer, Warsaw, Indiana) and high-flexion design in the other knee (Zimmer, Warsaw, Indiana). The null hypothesis leads to the conclusion that there is no difference in terms of the maximum knee flexion achieved between the standard version and high-flexion version total knee arthroplasty.

Materials and methods

This is a retrospective review to compare the range of motion after NexGen LPS and NexGen LPS-Flex total knee arthroplasty. The medical records from 2002 to 2004 in two district hospitals were reviewed. Patients were recruited into

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Fig. 1 The relationship between pre-operative maximum knee flexion and post-operative maximum knee flexion

the analysis if the following criteria were satisfied: (1) patients had received bilateral total knee replacement (either one stage or two stages), with the NexGen LPS standard version prosthesis implanted in one knee and the NexGen LPS-Flex version implanted in the contralateral knee, and (2) the diagnosis leading to the operation was primary osteoarthritis of the knee. Patients were excluded from the analysis if (1) there was a history of previous knee operation, (2) there was a significant complication in the early post-operative period and it led to a change in the rehabilitation protocol, (3) the patient defaulted on follow-up within a minimum period of 18 months, or (4) the total knee replacement had been revised.

All total knee replacements were performed using the medial para-patellar approach. All the patellae were routinely resurfaced in one hospital while they were not resurfaced in the other hospital. The rehabilitation protocol in both hospitals was similar with the initiation of active mobilisation of the knee in the early post-operative period. A continuous passive motion machine was not used in the post-operative period in either hospital. The active range of movement of the knees (including presence of fixed flexion contracture and maximum active flexion) were measured clinically by the use of goniometer in the pre-operative period and on the most recent follow-up.

The maximum active knee flexion on the most recent follow-up between the NexGen LPS standard version side and the NexGen LPS-Flex high-flexion version side was compared by using paired t-test. Statistical significance was assumed if the *p* value was found to be less than 0.05. A type II error was reported.

Results

Thirty-six patients satisfied the inclusion criteria and were recruited into the study. One patient was excluded because she defaulted on follow-up after discharge from the hospital. No patient suffered from significant post-operative complications requiring a change in rehabilitation protocol. No knee was revised. Thus, a total of 35 patients suffering from primary osteoarthritis of both knees were recruited. The results of 70 replaced knees (35 NexGen LPS standard version TKR in one knee and 35 NexGen LPS-Flex high-flexion version TKR in the contralateral knee) were available for analysis.

There were a total of 28 women and 7 men. Twenty patients received one stage sequential bilateral total knee replacements. Fifteen patients received two stage bilateral total knee replacements. (First stage is a standard version posterior stabilised knee and second stage is a high flexion version posterior stabilised knee). The mean age at the time of the operation was 68 years (range 53–82 years). The policy of patella resurfacing was the same in both knees of the same patient. There were 15 patients with the patellae of both knees resurfaced and 20 patients without. The average duration of the follow-up period was 35 months (range 20–53 months).

The mean preoperative fixed flexion deformity was 6° (range 0°–30°). The mean preoperative maximum flexion is 105° (range 70°–140°) (Fig. 1). There was no significant difference in the maximum knee flexion in the pre-operative period between knees receiving standard version total knee replacement and knees receiving high-flexion version total knee replacement (*p*=0.653, paired t-test).

Table 1 Range of motion

	Standard version posterior stabilised TKR group	High flexion version posterior stabilised TKR group	Paired t-test
Pre-operative maximum knee flexion	105°±15° (80°–140°)	104°±17° (70°–135°)	<i>P</i> =0.653
Post-operative maximum knee flexion	105°±13° (85° to 130°)	106°±14° (85°–135°)	<i>P</i> =0.201
Change in knee flexion range *	−0.5°±13° (−35° to +30°)	+2°±16° (−30° to +32°)	<i>P</i> =0.251
Pre-operative fixed flexion contracture	7°±7° (0° to 30°)	5°±6° (0°–20°)	<i>P</i> =0.06
Post-operative fixed flexion contracture	1°±3° (0° to 15°)	1°±2° (0°–10°)	<i>P</i> =0.447

*Negative values imply loss of flexion, positive values gain in flexion

Table 2 Potential factors affecting post-operative knee flexion

		Number of knees	Maximum post-operative knee flexion	Independent t-test
Pre-operative knee flexion	Pre-operative knee flexion equal or more than 120°	20	112°±15°	<i>P</i> =0.006
	Pre-operative knee flexion less than 120°	50	103°±12°	
Patella resurfacing policy	Patella resurfaced	30	103°±10°	<i>P</i> =0.092
	Patella not resurfaced	40	108°±15°	
Sex	Male	14	106°±17°	<i>P</i> =0.875
	Female	56	106°±12°	

The maximum knee flexion on the most recent follow-up of the knees receiving standard version total knee replacement was 105°±13°. The maximum knee flexion in the latest follow-up of the knees receiving high-flexion version total knee replacement was 106°±14°. No significant difference between the two groups was detected (*p*=0.201, paired t-test; beta error=0.073) (Table 1).

In the standard version posterior stabilised total knee replacement group, 12 knees exhibited an improvement in flexion range and 23 knees had either similar or loss of flexion as compared with the pre-operative knee flexion. On the other hand, in the high-flexion version posterior stabilised total knee replacement group, improvement in knee flexion was found in 16 knees. Similar or loss of flexion range was found in 19 knees. There was an average loss of flexion of 0.5° in the standard version group and an average gain of flexion of 2 degrees in the high-flexion version group (*p*=0.251, paired t-test; beta error=0.105).

The pre-operative knee flexion in 20 knees was equal to or greater than 120°. Significantly better knee flexion at the latest follow-up was observed in the group with high pre-operative knee flexion (*p*=0.006, independent t-test). However, even in the group of patients with high pre-operative knee flexion of equal to or greater than 120°, the high-flexion designed NexGen LPS-Flex TKR (113°±16°) did not demonstrate significantly better flexion range than its standard version counterpart (112°±14°) (*p*=0.739, Mann-Whitney test). Post-operative knee flexion was found not to be related to the sex (*p*=0.875, independent t-test) or whether the patella was resurfaced or not (*p*=0.092, independent t-test) (Table 2).

Significant improvement in flexion contracture was observed in both groups. The mean flexion contracture at the most recent follow-up was 1° (Table 1).

Discussion

There are many factors affecting the post-operative maximum flexion in total knee replacement. These include the degree of

preoperative knee flexion, diagnosis leading to the operation, design of the prosthesis, surgical technique, and the patient's motivation to carry out rehabilitation [4, 8, 9, 12].

The NexGen LPS-Flex high-flexion design prosthesis is a modification of the NexGen LPS standard version posterior stabilised prosthesis. The modification is intended to allow deep knee flexion to be exerted safely and, hopefully, also lead to a better knee flexion range after total knee replacement. The design of the tibial tray is identical in both the standard version and high-flexion version. The difference between the two versions lies in the design of the femoral component. An additional 2 mm of bone is removed from the posterior condyle during preparation of the distal femur. This allows an extension of the articular surface in the high-flexion design to facilitate deep flexion. The cam-post mechanism was modified to minimise the chance of posterior dislocation during deep knee flexion. It was demonstrated in an in vitro study that the kinematics of the NexGen LPS-Flex total knee system were similar to normal knees at high knee flexion [7].

However, does the modification of the design of the prosthesis essentially lead to an improvement in flexion range in patients receiving total knee replacement? The results from the literature are controversial [3, 5, 6, 10]. It was shown in our study that post-operative knee flexion was not related to the design of the prosthesis implanted (NexGen LPS: 105°±13° versus NexGen LPS-Flex: 106°±14°; *p*=0.210, paired t-test; beta error=0.073).

Among all the factors reported in the literature, the amount of pre-operative knee flexion seems to be the most consistent and significant factor in predicting the post-operative knee flexion after total knee replacement [6, 8, 9, 11, 12]. Many surgeons believe that the motivation of the patient is another important factor which affects the final flexion range after total knee arthroplasty. However, it is difficult to measure patient motivation quantitatively to allow accurate comparison. It is frequently observed that patients who are better motivated in the rehabilitation period and exhibit a higher tolerance to pain usually enjoy a superior flexion range at the final follow-up. The

experimental setting of comparing total knee prosthesis of two different designs in patients receiving bilateral total knee replacement minimises the effect of patient motivation. This provides the best case scenario to test the hypothesis about the effect of the design of the prosthesis on flexion range after total knee replacement, especially when the policy of patella resurfacing is identical in both knees. However, despite the use of this method in our study, the high-flexion design did not afford any advantage over the standard design in terms of the maximum post-operative knee flexion.

Ritter showed that the preoperative maximum knee flexion was predictive of the postoperative maximum flexion [8, 9]. In addition, it was found that there was tendency of a centralisation to occur in the post-operative knee flexion range. An average gain of 16° was reported when the preoperative maximum flexion was less than 75°, while an average loss of 8° was reported when the preoperative maximum flexion was more than 95° [8, 9]. A similar trend was observed in our study (Fig. 1). Those patients with poor preoperative maximum flexion tended to gain range while those with good preoperative maximum flexion tended to lose range regardless of the type of prosthesis implanted.

The high-flexion version of the NexGen posterior stabilised total knee prosthesis is designed to allow safe deep flexion. The advantage of the high-flexion design may not be obvious if the pre-operative knee flexion, and hence the anticipated post-operative flexion range, is poor. However, in this study, even in a group of patients with high pre-operative knee flexion of more than 120°, no statistically significant difference was found between the standard version posterior stabilised knee and the high-flexion version design in terms of the amount of deep flexion on the most recent follow-up.

Kim reported a randomised controlled trial comparing the LPS and LPS-Flex prosthesis in patients with good preoperative maximum flexion [6]. Their results showed that there was a difference in the maximum flexion achieved on the final follow-up regarding the type of prosthesis implanted (135.8° in the LPS prosthesis and 138.6° in the LPS-Flex prosthesis), although this was not statistically significant ($p=0.41$). We also observed a slight difference in the maximum post-operative knee flexion in the two groups (105° and 106°, respectively). There was a slight loss of average flexion in the LPS group (0.5°) and a slight gain in average flexion in the LPS-Flex group (2°). However, this was not statistically significant.

One merit of this study is the comparison of two different prosthesis designs in the same patient who had received bilateral total knee replacement. This helped to

minimise the persistently reported effect of patient's motivation on final knee flexion in the follow-up. However, the retrospective nature of the study, the small number of the cases recruited, the potential errors introduced by using a goniometer as the tool to measure the range of motion and the heterogeneous nature of the sample (15 patients received a two stage operation and 20 patients received a one stage operation) limit the scientific value in terms of the conclusions which can be drawn from it.

To conclude, in a group of patients with a majority having a pre-operative knee flexion of equal to or less than 130°, the use of a total knee replacement of high-flexion design exhibited no additional benefit in terms of post-operative knee flexion when compared with a standard version posterior stabilised total knee replacement prosthesis.

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