

Original Research Article

A comparison of the proprioception of osteoarthritic knees and post total knee arthroplasty

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ABSTRACT

Background: Proprioception of the knee joint is an important factor for establishing balance, and smooth walking. The effect of arthroplasty on proprioception can be a determinant of post-operative function and subjective feeling of the arthroplasty. We wished to check the status of osteoarthritic knees and how their proprioceptive function is, in comparison to knees post total knee replacement.

Methods: We compared 80 unilateral knee replacement patients with their osteoarthritic counterpart in the opposite knee. There was 50% Cruciate Retaining (n =40), Posterior Stabilized 50% (n =40). We assessed the proprioception using threshold to detection of passive motion and conscious awareness of passive joint position.

Results: 73.8% (n =59) of patients experienced a better joint position sense, 21% (n =17) had decreased joint position sense and 5% (n =4) had the same, when compared to the contralateral osteoarthritic knee. The mean of threshold to detection of passive motion was 2.16±0.68 for the replaced knees versus 2.72±0.61 for the contralateral osteoarthritic knee.

Conclusions: The proprioception of the knees that were replaced with arthroplasties had a better proprioceptive function than the osteoarthritic knees. This further solidifies the reasons to replace the dysfunctional osteoarthritic knee.

Keywords: Proprioception, Knee arthroplasty, Passive joint reproduction

INTRODUCTION

Proprioception is a word coined in the 1890 to explain the sensations of the joint that become stimuli for our brain to perceive the whereabouts of our joints and body. It originates from “proprius” which means one’s own. The standard definition of proprioception is the reception of stimuli produced in (an organism). Sir Charles Bell claimed limb position and motion to be the sixth sense after the 5 original senses as explained by Aristotle.

These sensations are said to be mediated by receptors called mechanoreceptors and free nerve endings. The

mechanoreceptors are of various types some of which reside in the joint capsule and ligaments, and some in the musculotendinous junction.¹

There is a substantial amount of evidence that shows the importance of proprioception for production of smooth, controlled and coordinated movements, maintenance of posture and motor learning and relearning. Some studies showed that deafferented patients had delayed movements and an inaccurate trajectory of movement.^{2,3}

The association of proprioception deficits and osteoarthritis is undeniable but what is still unclear is

which on is the result of which i.e. is the proprioceptive deficit a part of the etiology or the pathologic process? A longitudinal study with a large cohort failed to demonstrate that proprioceptive deficit is a risk factor for the development or progression of knee Osteoarthritis.⁴

Researchers supporting PCL-retaining TKA system argue that in the regular knee joint kinematics physiologic roll-back mechanism is preserved and adding that of the neurosensory properties when PCL is preserved, it is an advantage for the patients.⁵

METHODS

We included 80 primary unilateral knee replacements with osteoarthritis on the contralateral limb. All patients with morbid obesity (BMI >30) uncontrolled diabetes, neurological disorders or those who lacked mental capacity and cooperation. All the surgeries were performed by the same surgeon and the decision to do a PCL retaining or a PCL substituting knee was decided prior to the surgery.

The study was conducted in Sri Ramachandra University, Chennai from August 2015 to September 2016.

We assessed proprioception by conscious awareness of passive joint position and threshold to detection of passive motion.

The first method we used was of conscious awareness of passive joint position assessment. We performed a reproduction of passive motion by using a CPM Machine (knee flex) with a transducer to show the digital angle on a connected handheld device. The patient was blindfolded and given a noise cancelling headset (3 M). We demonstrated a position of 45° three times, for 10 seconds at a time. This would allow the slow adapting Ruffini corpuscles in the ligaments to adapt, and hence lead to memory of the joint position.⁶

Next the knee joint was brought to a relatively extended position and flexed as per CPM machine at a angular velocity of rate of 1° per second. The patient was asked to press the button on the handset or incase that was difficult, to make a Hand signal when they so perceived the angle of 45°. The angle 45 was chosen as to not put tension on the joint capsule. The difference of the perceived versus actual position showed on the handheld device, and the mean of the three trials were taken. This test was done for both the replaced knee and the contralateral non-operated osteoarthritic knee.

Table 1: Chart for the conscious awareness of passive joint assessment.

From flexion to 45	Angle recorded – operated knee	Mean difference from reference point – operated knee	Angle recorded – non operated knee	Mean difference from reference point non-operative knee
Test 1 (from 15°)				
Test 2 (from 20°)				
Test 3 (from 25°)				

Table 2: Chart for the threshold to detection of passive motion.

Movement from 45° to flexion	Threshold to recognition-operated knee	Mean threshold to recognition – operated knee	Threshold to recognition – non operated knee	Mean threshold to recognition –non operated knee
Trial 1				
Trial 2				
Trial 3				



Figure 1: Continuous passive motion instrument used, with noise cancelling headset.

The second factor that we checked was Threshold to detection of passive motion. We placed the knee at 45° flexed positions and started to flex the knee slowly at a rate of 1° per second and as soon as the patient recognized the movement of his knee, he would as done prior, raise his hand or press the stop button on the handheld device. This test was performed for both the operated and non-operated osteoarthritic knee (Table 2).

The results were measured with Mann Whitney test and paired sample statistics on statistical tool SPSS (IBM).

RESULTS

73.8% (n =59) of patients with knee prostheses experienced a better proprioceptive ability, 21% (n =17) had decreased proprioceptive function and 5% (n =4) had the same proprioceptive function when compared to the opposite osteoarthritic knee.

Table 3: Results comparing passive joint position reproduction and surgery.

Joint position reproduction assessment	Type of surgery		Total (%)
	CR (%)	PS (%)	
Improved	27 (67.5)	32 (80)	59 (73.8)
Not improved	10 (25)	7 (17.5)	17 (21.3)
Same	3 (7.5)	1 (2.5)	4 (5)
Total	40	40	80

We noticed that 67.5% of patients with cruciate retaining implants had an improved Joint position sense compared with the contralateral non-operative osteoarthritic knee. 80% of patients with posterior stabilized knees had an improved joint position sense compared with contralateral osteoarthritic knee.

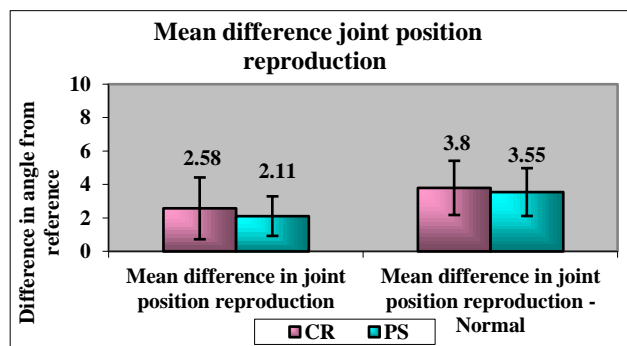


Figure 2: Bar diagram comparing mean difference in joint position of replaced knees and their osteoarthritic counterparts.

The Mean value for threshold to detection of passive motion of non-operated osteoarthritic knees was 2.72° with a standard deviation of 0.619 and that of operated knees was 2.16° with a standard deviation of 0.685. There was significant p value of 0.005.

Table 4: Results of threshold to detection of passive motion of knees after knee replacement and osteoarthritic knees.

Type of surgery	N	Mean	Std. deviation	SEM	
Operated	CR	40	2.13	0.723	0.114
	PS	40	2.20	0.648	0.103
Non operated	CR	40	3.00	0.608	0.096
	PS	40	3.00	0.630	0.100

We also compared the mean value of threshold to detection of passive motion for cruciate retaining implant which was $2.13^{\circ} \pm 0.72$ to that of posterior stabilized implants with $2.20^{\circ} \pm 0.64$ degrees with an insignificant p value of 0.668.

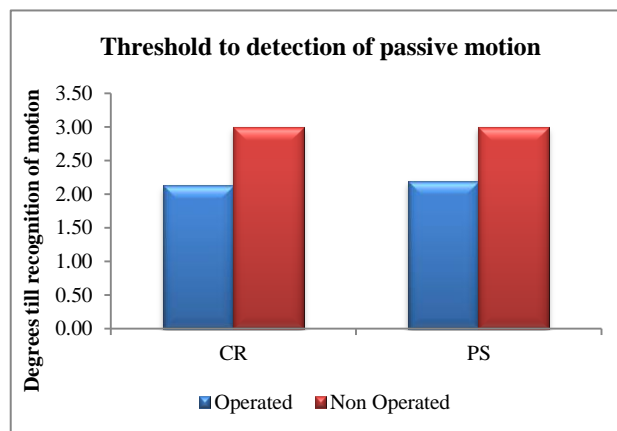


Figure 3: Bar diagram comparing threshold to detection of passive motion of knees after replacement and the osteoarthritic knees.

DISCUSSION

We will discuss about posterior stabilized and cruciate retaining total knee replacements under 2 parameters. The first one being a mean difference in joint position sense from the reference point and the second a threshold to detection of passive motion.

We compared the mean difference in joint position sense of the knee replacement on one side versus the contralateral osteoarthritic knee. There was a significantly better proprioception in the group for which total knee replacement was done. There was an improvement in joint position sense of 73.8% (n =59) of our patients who underwent knee arthroplasty. We also compared the cruciate retaining implants versus the posterior stabilized patients, 67.5% of cruciate retaining implants had a better joint position sense whereas, 80% of the posterior stabilized knees showed a better proprioception when compared to the contralateral non-operative osteoarthritic side. This was probably indicative of the higher grades of osteoarthritis in those opposite knees, as the more severe initial osteoarthritis, the worse the proprioceptive deficit is. The other reasons for a possible restoration of joint sensation after total knee arthroplasty could be elimination of deleterious factors in elderly and osteoarthritic factors.^{7,8}

This was similar to the study by Simmons et al. who when performing threshold to detection of passive motion. They reported nearly identical postoperative scores in those with modest arthritis whereas those with initial severe preoperative arthritis performed better with cruciate sacrificing implants.⁹ This was a surprise to them

and they hypothesised that any proprioception originating in the cruciate ligaments was lost in early degenerative process, as also shown by Kleinbart histologically.¹⁰

Mean difference in joint position sense from the reference point. In our study, the mean difference from the reference point for passive reproduction of joint position or joint position sense was 2.58 degrees with a standard

deviation of 1.85 degrees for those with cruciate retaining implants and 2.11 degrees with a standard deviation of 1.18 degrees for those with posterior stabilized implants, but the p value was 0.183 which was insignificant.

Thus in our study there was no difference in the joint position sense for either the posterior cruciate retaining or sacrificing/substituting implants.

Table 5: Comparison of the results from our study with another study.

Test performed	Non-operative value - CR	Operative Value-CR	Non-operative value -PS	Operative value -PS	Preoperative value-Swanik	Postoperative value-Swanik
Passive joint reproduction position	3.8±1.62	2.58±1.85	3.55±1.43	2.11±1.18	2.62±1.48	2.20±1.34
Threshold to detection joint movement	2.70±0.723	2.13±0.723	2.75±0.630	2.20±0.648	3.22±2.02	1.66±0.99

Table 6: Comparison of the recent results of proprioception differences.

Study name	Method of testing	Proprioceptive difference between before and after TKR	Groups examined	Difference between groups
Ishi et al¹²	Joint position sense	None	PCL retaining and sacrificing	None
Cash et al¹³	Threshold to detection of passive motion	None	PCL retaining and sacrificing	None
Simmons et al⁹	Threshold to detection passive motion	-	Unicondylar; PCL retained; PCL sacrificed	None
Warren et al¹¹	Joint position sense	Improved	-	-
Attfield et al¹⁴	Joint position sense	Improved	-	-
Barett et al¹⁵	Joint position sense	Improved	PCL retaining and sacrificing	PCL retained was better
Lattanzio et al¹⁶	Joint position sense		PCL retaining and sacrificing	None
Swanik et al⁷	Joint position sense and Threshold to detection of passive motion	Improved	PCL retaining and sacrificing	None
Wada¹⁷	Joint position sense		PCL retaining and sacrificing	None

This is comparable to Swanik and others who showed when PCL retention was compared to the patients with posterior stabilized total knee design there was no significant improvement in proprioception in Table 5.⁷

This however is not indicative of a lack of proprioceptive benefit of the posterior cruciate ligament. Warren et al reported a comparative study of 20 PCL Retaining and 20 PCL substituting TKA's and concluded knees in which the PCL was retained had a greater improvement in joint position sense.¹¹

This is in contradiction to the study by Ishii et al. They investigated the joint position sense before and after TKA on patients with semi constrained total knee arthroplasty,

and stratified the knees into those that are semi constrained and into those with or without remaining posterior cruciate ligaments. They reported that there was no significant improvement of joint position sense among all the arthroplasty groups and concluded that the knee arthroplasty did not affect joint position sense.¹²

Threshold to detection of passive motion

The non-operative osteoarthritic knees had a mean threshold to detection of 2.70±0.608 compared to the operated knees 2.13±0.723. There was a difference in the mean values of the operated knees and the non-operated osteoarthritic knees with a significant p value of <0.005. This is similar to the study by Swanik et al which showed

a level of better proprioception of postoperative knees compared to that of preoperative knees.⁷

This was in contradiction to Cash et al. showed that substitution or retention of the PCL made no clinical difference in proprioception as measured by testing threshold to passive motion.¹³ The report by Simmons et al has a similar conclusion. They compared unicondylar and total knees with and without PCL retention using threshold to detection of motion. He reported no difference in values across the three groups, suggesting that PCL retention had no advantage in the betterment of proprioception.

In our study, the mean threshold for detection of motion for the implants with cruciate retaining was 2.13 ± 0.723 and that of posterior stabilized was 2.20 ± 0.648 . There was an insignificant p value for the difference. This is comparable to Swanik's value of postoperative 1.66 ± 0.99 . There was no difference in our values which indicated no proprioceptive difference between the posterior stabilized and cruciate retaining implants in concert with Swanik et al.⁷

Limitations

There were a few limitations in our study:

The first of which was that the study was a cross sectional study, assuming the contralateral non-operative osteoarthritic knee to be indicative of the preoperative osteoarthritic knee.

The second limitation was the method of checking the passive reproduction of motion with continuous passive motion, while being the closest technically sound substitute for the evaluation of passive motion, there was also a flexion of the hip occurring simultaneously, which despite being checked to be normal may have been a variable.

The third limitation was that we require a long term follow up to assess the continued function of the posterior cruciate ligament in cruciate retaining prosthesis as the age progresses.

CONCLUSION

There was an increased accuracy of passive reproduction of joint position and a better threshold to detection of passive motion in the replaced knees when compared with the contralateral non-operative osteoarthritic knees, which indicates an improvement of proprioception post knee replacement.

The second conclusion was that there was no difference in passive reproduction of joint position or threshold to detection of passive motion among both the cruciate retaining and cruciate substituting groups, which suggests no difference in proprioception between them.

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Ethical approval: The study was approved by the institutional ethics committee

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