The Journal of Arthroplasty 29 (2014) 548–552

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Clinical, Objective, and Functional Outcomes of Manipulation Under Anesthesia to Treat Knee Stiffness Following Total Knee Arthroplasty

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ARTICLE INFO

Article history:
Received 25 April 2013
Accepted 30 July 2013

Keywords:
manipulation under anesthesia
total knee arthroplasty
flexion
range-of-motion
knee stiffness
arthrofibrosis

ABSTRACT

The purpose of this study was to determine the clinical outcomes of manipulation under anesthesia (MUA) in a cohort who had developed knee stiffness following total knee arthroplasty (TKA). One-hundred and forty-five TKAs in 134 patients who had undergone MUA were compared to the remaining 1973 TKAs in 1671 patients who did not develop this condition. At a mean follow-up of 51 months (range, 24 to 85 months), the mean gains in flexion in the MUA cohort were 33° (range, 5° to 65°). The final range-of-motion in the MUA cohort was lower than the comparison cohort (114° versus 125°) however, this would meet the required flexion for activities of daily living. There were no differences in the Knee Society objective and functional scores between the two cohorts. It is encouraging that MUA cohort outcomes were comparable to outcomes of patients who did not develop knee stiffness.

Total knee arthroplasty (TKA) is considered to be one of the most successful orthopaedic procedures that reliably alleviates pain and restores function in patients who have degenerative knee arthritis [1–5]. However, knee stiffness following total knee arthroplasty, may lead to sub-optimal functional outcomes and decreased patient satisfaction [6–8]. Despite improvements in prosthetic design and instrumentation in modern TKA, various studies have reported post-operative knee stiffness to occur in up to 25% of patients [9–11]. Numerous pre-operative, intra-operative, and post-operative factors have been described that may affect final range-of-motion [12–18].

Although the standard initial non-operative treatment option for post-operative knee stiffness following TKA is physical therapy, manipulation under anesthesia is the least invasive operative procedure [19], with the remaining more invasive methods reserved for failed non-operative treatment, late presentation, implant malalignment, or technical concerns [20,21]. However, only a limited number of studies have compared improvements in range-of-motion after MUA to patients who did not develop knee stiffness after total knee arthroplasty [22,23]. Moreover, objective and functional outcomes of MUA for post-TKA knee stiffness have also not been widely reported [22,23]. Nevertheless, these metrics may be valuable to analyze overall outcomes of MUA.

Therefore, we attempted to assess the clinical, objective, and functional outcomes of MUA in patients who had developed knee stiffness after their index knee arthroplasty procedure. We compared these outcomes to all remaining patients who had not developed knee stiffness. Specifically, we evaluated: (1) mean gains in flexion after MUA; (2) range-of-motion at final follow-up in both groups; (3) clinical outcomes measures by the Knee Society objective and functional scores in both groups, and (4) MUA complications.

Methods

To determine the number of patients who had undergone manipulation under anesthesia (MUA) at our institution, we reviewed our prospectively collected database of 2118 primary total knee arthroplasties (TKA) that were performed by three experienced, fellowship-trained arthroplasty surgeons (MAM, RED, and HSK) between 2005 and 2011. One-hundred and forty nine manipulations in 138 patients were identified. Four patients (4 MUA) had flexion contractures of greater than 10°. We had attempted to report the mean gains in flexion range-of-motion in patients who had developed knee stiffness in the absence of flexion contracture. Thus, in order to have a more homogenous cohort, these 4 patients were excluded from this study. The remaining 145 manipulations were performed in 46 men and 88 women who had a mean age of 55 years (range, 25 to 89 years) and a mean body mass index (BMI) of 32.9 kg/m^2 (range, 18 to 51 kg/m^2). All these patients had a mean flexion contracture of two degrees (range, 0° to 9°) and the mean follow-up was 51 months

The Conflict of Interest statement associated with this article can be found at http://dx.doi.org/10.1016/j.arth.2013.07.046.

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0883-5403/2903-0020$36.00/0 – see front matter © 2014 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.arth.2013.07.046

(range, 24 to 85 months). Appropriate institutional review board approval was obtained for the study of these patients (Table 1).

We had assessed the following parameters: mean pre-TKA range-of-motion, mean gains in flexion compared to pre-TKA range-of-motion, mean gains in flexion compared to pre-MUA range-of-motion, final follow-up range-of-motion, and clinical outcomes measured by Knee Society pain and functional scores [24]. All these metrics were compared between the MUA cohort and the remaining comparison cohort of 1973 TKAs in 1671 patients (1178 women and 493 men) who did not develop knee stiffness. The comparison cohort comprised of cases performed during the same time period (2005–2011) and only primary TKAs were evaluated and no revision patient was included. These patients had a mean age of 61 years (range, 34 to 88 years) and a mean BMI of 32.4 kg/m^2 (range, 16 to 54 kg/m^2). MUA patients were significantly younger ($P = 0.01$), however, there were no significant differences in male to female ratio ($P = 0.22$) or BMI between the two cohorts ($P = 0.16$). The underlying causes of TKA in the MUA and the comparison cohorts were end-stage osteoarthritis in 127 and 1656 patients and osteonecrosis in 6 and 15 patients, respectively. MUA patients had a higher odds ratio of osteonecrosis ($P = 0.003$). In the MUA cohort, 29 patients (34 TKAs) and in the comparison cohort 274 patients (324 TKAs) had diabetes and this difference was statistically significant ($P = 0.03$). However, there were significant differences in mean pre-TKA range-of-motion between the MUA and comparison cohorts ($P = 0.02$). The mean pre-TKA range-of-motion in the MUA cohort was 101° (range, 60° to 135°) which was significantly lower than the 111° (range, 55° to 145°) in the comparison cohort ($P = 0.02$) (Table 2).

In the MUA and comparison cohorts, all patients received cemented total knee arthroplasty prosthetic components (103 and 1361 knees had received Triathlon prostheses, Stryker Orthopedics, Mahwah, New Jersey; 25 and 323 knees had received Scorpio prostheses, Stryker Orthopedics, Mahwah, New Jersey, and 18 and 296 knees had received NexGen prostheses, Zimmer, Warsaw, Indiana, respectively), with the use of standard universal cutting blocks. There were no significant differences in rate of MUA per prosthesis in our cohort ($P = 0.46$ to 0.81). Range-of-motion at skin closure for both groups was greater than 120°. All patients in both groups had received similar general anesthesia protocols based on standard of care. The pain management protocols for both patient cohorts were also similar multimodal non-steroidal anti-inflammatory medications.

In our institution, all surgeons have a low threshold for performing MUAs if flexion ROM was assessed to be less than 110° at 6-week post-TKA follow-up. Nevertheless, the absolute and relative indications for undergoing manipulation under anesthesia were flexion range-of-motion of less than 90° and 115°, respectively, and/or presence of religious, cultural, or personal reasons that would require higher range-of-motion for certain patients (e.g. kneeling, etc.). Some patients had met absolute indications for MUA but had denied treating surgeon's recommendation to undergo the procedure. All manipulations were performed at approximately median of 5.5 weeks (range, 3 to 48 weeks) from the index knee arthroplasty procedure. The effect of timing of manipulation on the outcomes is the subject of another manuscript.

All manipulations were performed according to a similar technique described by Fox et al where after adequate anesthesia and muscle relaxation, by holding the middle to proximal-third of tibia, the knee was slowly and gently flexed until audible and palpable separation of the adhesions was heard [11]. Range-of-motion was measured by the same treating surgeons or their physician assistants who have extended experience with total knee arthroplasty and by using a goniometer. The mean immediate post-manipulation flexion range-of-motion for all patients was approximately 120° ± 5°. Post-MUA plain knee radiographs were obtained to rule-out any potential fractures. Ice-packs were always applied over the knee to decrease swelling for 30 min post-manipulations.

Post-manipulation rehabilitation protocol for all patients was started during the same day of procedure which emphasized early fully weight-bearing, 2 weeks of continuous-passive-motion (CPM), non-steroidal inflammatory medication to reduce pain and inflammation, and 4 weeks of quadriceps strengthening and range-of-motion exercises.

All patients returned for follow-up office visits at approximately six weeks, three months, six months, and then yearly thereafter. During each follow-up visit, patients were examined thoroughly and flexion-arc range-of-motion and Knee Society pain and functional scores were recorded [24]. Since there were minimal and non-significant differences in range-of-motion between annual follow-ups ($P = 0.21$ to 0.76), only the most recent values were used for the purpose of this study (Fig. 3).

The standardized list and definitions of the Knee Society were used to evaluate potential complications of MUA which included conditions such as neural deficit, bleeding, wound complications, instability, venous thromboembolic disease, infection, fracture, or implant loosening [25].

All data were recorded using an Excel spreadsheet (Microsoft Corporation, Redmond, Washington). Statistical data analysis was performed by using a Fisher's exact test and paired two-tailed Student's *t*-tests to evaluate pre-manipulation and post-manipulation range-of-motion, improvement in final range-of-motion, and Knee Society pain and functional scores between patients who had

Table 1
Comparison of Pre-Operative and Intra-Operative Findings Between the MUA and Comparison Cohorts.

Metrics	MUA Cohort	Comparison Cohort	*P* Value
Number of procedures	145	1973	–
Male to female ratio	44:88	478:1178	0.22
Mean age in years (range)	55 (25–89)	61 (34–92)	0.01
Mean body mass index in kg/m^2 (range)	32.9 (18–51)	32.4(16–54)	0.16
Diagnosis (patients)			0.003
Osteoarthritis (% of group)	127 (95.4)	1656 (99.1)	
Osteonecrosis (% of group)	6 (4.6)	15 (0.9)	
Range-of-motion at skin closure	All >120°	All >120°	–
Releases	Data not available	Data not available	–
Prostheses			
Triathlon (% of group)	103 (70.5)	1361 (68.7)	0.64
Scorpio (% of group)	25 (17.1)	323 (16.3)	0.81
NexGen (% of group)	18 (12.4)	296 (15)	0.46

Table 2
Comparison of Clinical Outcomes Between the MUA and Comparison Cohorts.

	MUA Cohort	Comparison Cohort	*P* Value
Mean pre-TKA range-of-motion in degrees (range)	101 (60–125)	110 (55–145)	0.02
Mean gains in flexion compared to pre-TKA range-of-motion in degrees (range)	13 (8–41)	14 (10–45)	0.07
Mean range-of-motion at final follow-up in degrees (range)	114 (85–134)	125 (110–165)	0.001
Mean preoperative Knee Society function score points (range)	44 (25–62)	45 (30–66)	0.32
Mean preoperative Knee Society objective score points (range)	43 (31–67)	44 (29–64)	0.29
Mean postoperative Knee Society function score points (range)	88 (72–100)	89 (70–100)	0.21
Mean postoperative Knee Society function score points (range)	89 (70–100)	90 (74–100)	0.18

MUA, manipulation under anesthesia; TKA, total knee arthroplasty.