Return to Driving After Hip Arthroscopy

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Abstract

Objective: The objective of this study was to evaluate patients' braking performance using a modern driving simulator after undergoing a right hip arthroscopy. **Design:** This prospective study included 5 total driving sessions at which measurements were taken. **Setting:** The study was conducted at an academic medical center. **Patients:** A total of 14 patients scheduled to undergo a right hip arthroscopy were enrolled and compared with a control group of 17 participants to account for a potential learning phenomenon. **Interventions:** Patients drove in the simulator preoperatively to establish a baseline, and then drove again at 2, 4, 6, and 8 weeks postoperatively. The control group did not undergo any type of surgical procedure. The main independent variable was time from surgery. **Main Outcome Measures:** A modern driving simulator was used to measure initial reaction time (IRT), throttle release time (TRT), foot movement time (FMT), and brake travel time (BTT). The braking reaction time (BRT) was calculated as the sum of IRT + TRT + FMT, and the total braking time (TBT) was calculated as the sum of BRT + BTT. **Results:** The experimental group showed no significant changes in BTT ($P = 0.11$, $\eta^2_G = 0.04$) nor TBT ($P = 0.20$, $\eta^2_G = 0.03$) over the duration of 8 weeks. Although the experimental group did exhibit significant improvements in IRT ($P = 0.002$), TRT ($P < 0.0001$), FMT ($P < 0.0001$), and BRT ($P = 0.0002$) between preoperative and 2 weeks postoperative driving sessions, there were no significant changes thereafter. The mean preoperative TBT and 2 weeks postoperative TBT for the experimental group were 3.07 seconds (SD = 0.50) and 2.97 seconds (SD = 0.57), respectively. No learning phenomenon was observed in the control group. **Conclusions:** This study's findings suggest that patients may return to driving 2 weeks postoperatively from a right-sided hip arthroscopy procedure.

Key Words: return to driving, hip arthroscopy, simulator

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INTRODUCTION

Hip arthroscopy is an increasingly common procedure performed to help alleviate hip pain, with a 365% increase in the rate of hip arthroscopy performed between 2004 and 2009.[1] However, activities are usually limited during recovery. Patients commonly ask when they can return to driving, but physicians lack evidence to support an answer. By contrast, numerous studies have been published examining return to driving after hip arthroplasty,[2,3] knee arthroplasty,[4] knee arthroscopy,[5] and foot and ankle surgery.[6,7]

Furthermore, return to driving can have legal implications for both the physician and the patient.[8] If the physician clears a patient to drive and patient is involved in a crash, then the physician may expose himself to legal liability. Insurance companies will generally leave the decision with the patient, but the details of patient liability remain unclear.

The purpose of this study was to evaluate patients' braking performance using a modern driving simulator after undergoing a right hip arthroscopy. Our hypothesis was that patients would initially exhibit a decrease in braking performance but recover and show significant improvements by 4 weeks postoperatively.

METHODS

Institutional review board approval was obtained before initiating the study. We prospectively enrolled 14 patients scheduled to undergo a right-sided hip arthroscopy procedure between October 2014 and November 2015. Inclusion criteria included age between 16 and 60 years, licensed driver, and regular use of automatic transmission. Exclusion criteria included any previous ipsilateral limb surgery, pregnancy, and inability to follow-up at 2-week intervals for a total of 8 weeks. All hip arthroscopies were performed by a single surgeon at 1 institution. Procedures performed included labral repair with osteoplasty (8), labral repair with osteoplasty and iliopsoas release (3), labral repair and iliopsoas release (1), iliopsoas release (1), and labral debridement with osteoplasty (1). Patients were allowed to weight bear as tolerated with crutches for 2 weeks postoperatively and subsequently were transitioned to full weight bearing without crutches. A control group comprised 17 healthy volunteers who denied musculoskeletal problems was also used to evaluate the baseline differences and to evaluate for improvements in driving

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This study was approved by our IRB and was assigned protocol number X140602007.

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performance that could be attributed to a learning phenomenon. These control patients were recruited from the ancillary staff pool in the sports medicine clinics. Both groups were asked to fill out an informational form, and data were collected on sex, height, weight, and years since licensure, and number of previous driving violations and motor vehicle crashes since licensure (regardless of fault).

A modern driving simulator system (Systems Technology Inc, Hawthorne, California) was used to evaluate the driving performance. The simulated environment was displayed on 3, 20-inch liquid crystal display computer monitors, providing a 135-degree field of view. Figure 1 displays a picture of the driving simulator. The simulator provided dashboard instruments, including a speedometer and tachometer, as well as a steering wheel, accelerator, and brake pedals. Audio of naturalistic engine sounds, passing traffic, and external road noise was provided by an on-board stereo system.

Patients in the experimental group drove in the driving simulator preoperatively to establish a baseline, and then drove again at 2, 4, 6, and 8 weeks postoperatively for a total of 5 driving sessions. The control group also underwent 5 total driving simulator sessions, each 2 weeks apart, but did not undergo any type of surgical procedure. All participants were asked to refrain from using any pain medications on the days of simulator sessions. Before each session, the participants were asked to fill out a pain score from 1 to 10 using a visual analog scale (VAS).

The simulator session entailed a driving session of approximately 10 minutes through a suburban type environment. Figure 2 displays a screenshot of the driving simulator scenario. To test braking time specifically, a stop sign was flashed across the screen randomly a total of 3 times throughout the session, signifying to the participant to fully press the brake pedal as quickly as possible. The mean braking reaction times (BRTs) were calculated from these 3 occurrences. Before the first simulator session, the participant practiced this situation under supervision by a laboratory member to confirm understanding of instructions. Specific variables measured during these simulator sessions included initial reaction time (IRT) (time between stimulus and initiation of release of accelerator), throttle release time (TRT) (time from initiation to full release of foot from accelerator), foot movement time (FMT) (time between release of accelerator and initial contact with brake), and brake travel time (BTT) (time to apply 200 N force[9] from initial brake press). The BRT was calculated as the sum of IRT + TRT + FMT, whereas the total braking time (TBT) was calculated as the sum of BRT + BTT.[7]

Figure 1. Picture of the driving simulator set-up.

Figure 2. Screenshot of the driving simulator scenario.

Descriptive statistics for participant demographics and BRT variables were obtained, and associations were assessed in SAS 9.3 (Cary, North Carolina). Differences between groups for continuous variables were assessed with *t* tests, and associations between categorical variables were assessed with χ^2 tests of association. All statistical analyses were conducted with $\alpha = 0.05$, where P values < 0.05 were considered statistically significant.

Repeated-measures analyses of variance (ANOVAs) were conducted on IRT, TRT, FMT, BTT, BRT, and TBT. The repeated-measures ANOVA assumption of sphericity was assessed with Mauchly test, and the Greenhouse–Geisser (G–G) correction was used to interpret hypothesis tests when sphericity was violated. To determine if reaction times significantly improved over time, the first drive (preoperative) was considered the referent. In lieu of a post hoc power analysis, effect sizes were calculated using generalized eta squared (η^2_G),[10,11] where conventions of 0.02 = small effect, 0.13 = medium effect, and 0.26 = large effect were used.[12] To assess for a learned phenomenon effect, a mixed-effect regression analysis was performed using the control group data.

RESULTS

The final sample size included 14 experimental patients and 17 controls. Among the experimental patients, 4 subjects dropped out because of simulation sickness/nausea (1), scheduling issues (1), and loss of interest (2). The 2 groups did not differ in age, sex, height, weight, and driving experience as measured by years since licensure. The control participants reported significantly more previous motor vehicle crashes ($P < 0.001$) and previous driving violations ($P < 0.001$) than the experimental participants (Table 1).

At baseline, control participants had significantly faster IRT ($P = 0.02$), TRT ($P = 0.0002$), FMT ($P < 0.0001$), BRT ($P < 0.0001$), BTT ($P = 0.001$), and TBT ($P < 0.0001$) when

TABLE 1. Descriptive Statistics for Demographic Variables of Experimental and Control Group

	Experimental (n = 14)			Control (n = 17)					
Variable	Mean (SD)	n (%)	Range	Mean (SD)	n (%)	Range	*t* or χ^2	*P*	Effect Size
Age, yrs	27.39 (9.13)		17-44	28.35 (5.81)		19-44	0.79	0.43	0.07
Female		11 (79)			13 (76)		0.10	0.76	OR: 0.89 (95% CI, 0.41-1.89)
Height, inches	66.79 (3.55)		61-75	67.26 (3.92)		61-75	0.79	0.43	0.06
Weight, pounds	162.1 (21.06)		125-205	166.6 (45.71)		100-255	0.78	0.44	0.06
Years since licensure	12.12 (8.86)		2-28	12.29 (5.81)		3-28	0.14	0.89	0.05
Motor vehicle crashes*	0.93 (0.97)		0-3	1.71 (0.83)		0-3	**5.39**	**<0.0001**	**0.65**
Driving violations*	0.79 (0.68)		0-2	1.82 (1.47)		0-5	**5.79**	**<0.0001**	**0.66**

Bold indicates P < *0.05.*
** Self-reported number since licensure.*
CI, confidence interval; OR, odds ratio.

compared with the experimental group. The mixed-effects regression analysis indicated that the control group did not significantly improve in TBT from session to session over the 8 weeks ($P = 0.54$), suggesting that no learning phenomenon effect took place.

Experimental participants exhibited no significant change in BTT ($P = 0.11$, $\eta^2_G = 0.04$) nor TBT ($P = 0.20$, $\eta^2_G = 0.03$) over the duration of the 8 weeks. Figure 3 displays the TBT for each driving session for the experimental group. The experimental group did not exhibit any decline in any of the braking performance variables measured between preoperative and 2 weeks postoperative driving sessions.

The experimental group did show a significant improvement in IRT ($P = 0.002$), such that week 2 postoperative IRT (M = 0.42, SD = 0.12) was significantly faster than preoperative IRT (M = 0.47, SD = 0.06) ($P = 0.03$), but there was no significant improvement between week 2 postoperative IRT and week 4 (M = 0.45, SD = 0.05) ($P = 0.15$, $\eta^2_G = 0.03$).

The experimental group also demonstrated an improvement in TRT ($P < 0.0001$). Week 2 postoperative TRT (M = 0.57, SD = 0.08) was significantly faster than preoperative TRT (M = 0.61, SD = 0.04) ($P < 0.0001$), but there was no significant improvement between week 2 postoperative TRT and week 4 (M = 0.56, SD = 0.05) ($P = 0.40$, $\eta^2_G = 0.01$).

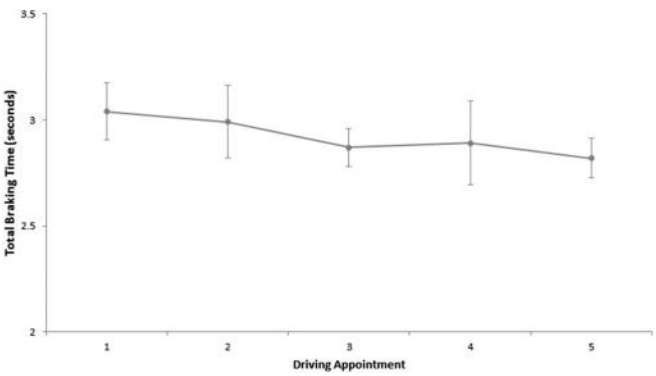

Figure 3. The line graph displays the TBT (seconds) for the experimental group during the preoperative driving appointment (1) and at subsequent driving appointments spaced approximately 2 weeks apart. Standard error bars are also displayed.

The experimental group exhibited a significant change in FMT ($P < 0.0001$) with week 2 postoperative FMT (M = 0.84, SD = 0.16) significantly faster than preoperative FMT (M = 0.88, SD = 0.12) ($P = 0.001$). However, there was no significant improvement between week 2 postoperative FMT and week 4 (M = 0.83, SD = 0.10) ($P = 0.23$, $\eta^2_G = 0.02$).

In addition, experimental participants demonstrated an improvement in BRT between the first 2 driving sessions ($P = 0.0002$) with week 2 postoperative BRT (M = 1.84, SD = 0.30) significantly faster than preoperative BRT (M = 1.96, SD = 0.18) ($P = 0.0001$). There was no significant improvement between week 2 postoperative BRT and week 4 (M = 1.84, SD = 0.14) ($P = 0.87$, $\eta^2_G = 0.0004$). The mean values for each variable are displayed in Table 2.

Before all simulated driving appointments, experimental participants reported significantly more pain than control patients ($P = 0.001$). No control participants reported pain at any appointment. Self-reported pain, measured using a VAS, decreased over time for those in the experimental group ($P = 0.03$) (Figure 4). Reported medication usage at each driving appointment is displayed in Table 3. No participants in the control group reported any medication usage at any driving appointment.

DISCUSSION

We used an immersive, realistic driving simulator to determine what effect, if any, a right-sided hip arthroscopy procedure may have on driving performance, specifically measured by braking maneuvers. This is the first study to address this topic specifically for hip arthroscopy. These data suggest that most patients may return to driving 2 weeks after a right side hip arthroscopy procedure, as indicated by their braking performance.

Previous studies have examined return to driving after hip surgery but only in the context of hip arthroplasty. A recent study by Hernandez et al[2] stated that patients could return to driving 2 weeks after total hip arthroplasty. Ruel et al[3] also conducted a return to driving study after hip arthroplasty and concluded that patients could return to driving after 4 weeks. However, these studies were limited by lack of a control group. Our study included a control group that underwent sequential simulator sessions to exclude the potential of a learning phenomenon. Previous studies have also been limited by a simulator set-up that was of low fidelity, often

TABLE 2. Mean Values for Each Driving Variable

	Week				
	Preoperative	2 wks	4 wks	6 wks	8 wks
Variable	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
IRT					
Experimental	0.47 (0.07)	0.42* (0.12)	0.45 (0.05)	0.41 (0.10)	0.45 (0.06)
Control	0.44 (0.09)	0.43 (0.09)	0.42 (0.05)	0.39 (0.09)	0.42 (0.07)
TRT					
Experimental	0.61 (0.04)	0.57* (0.08)	0.56 (0.05)	0.55 (0.04)	0.57 (0.05)
Control	0.58 (0.05)	0.54 (0.04)	0.54 (0.03)	0.54 (0.10)	0.52 (0.08)
FMT					
Experimental	0.88 (0.12)	0.84* (0.17)	0.83 (0.10)	0.90 (0.22)	0.85 (0.13)
Control	0.77 (0.11)	0.72 (0.12)	0.73 (0.09)	0.77 (0.15)	0.76 (0.14)
BRT					
Experimental	1.96 (0.18)	1.84* (0.30)	1.84 (0.14)	1.86 (0.25)	1.86 (0.17)
Control	1.77 (0.18)	1.72 (0.17)	1.71 (0.11)	1.67 (0.27)	1.69 (0.26)
BTT					
Experimental	1.08 (0.32)	1.14 (0.37)	1.03 (0.21)	1.12 (0.62)	1.00 (0.25)
Control	0.91 (0.29)	0.86 (0.19)	0.92 (0.33)	0.96 (0.30)	0.84 (0.19)
TBT					
Experimental	3.04 (0.50)	2.99 (0.64)	2.87 (0.34)	2.89 (0.74)	2.82 (0.35)
Control	2.69 (0.46)	2.62 (0.33)	2.67 (0.41)	2.62 (0.53)	2.47 (0.46)

** Indicates where experimental participants significantly improved from preoperative drive ($P < 0.05$).*

relying on patients to perform a simple task of responding to a light that changes from green to red.[2] Our study used a more realistic driving simulator experience having the participant negotiate a suburban driving environment. To mimic everyday driving situations, unexpected stimuli were presented at random, requiring emergency braking by participants.

No single standard for safe BRTs is legally mandated or universally accepted. Proposed national and international thresholds for safe BRTs vary from 750 to 1500 ms.[8] Our average BRT was 1980 and 1790 ms preoperatively in the experimental and control groups, respectively, which is much higher than these proposed thresholds. One explanation is simply the variability between simulator set-ups and measurement techniques. For example, the use of a simulator in which the participant is driving and presented with stimuli likely increases BRT when compared with a simulator where participants solely focus on a single light changing color. Nonetheless, we specifically looked at changes in braking performance and not meeting a specific quantitative threshold. Thus, the absolute quantitative values for BRT are less important.

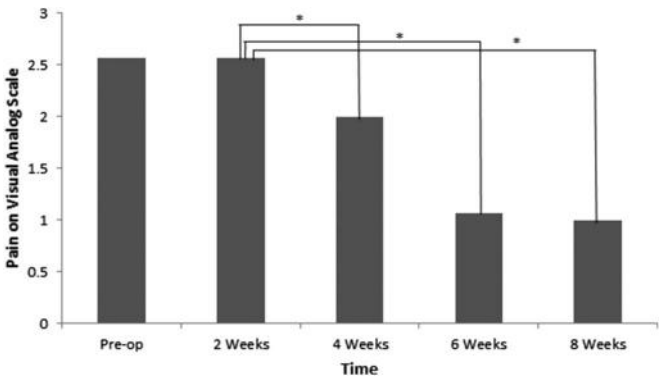

Figure 4. Self-reported pain using the VAS for the experimental group.

Interestingly, the experimental group demonstrated improvements in several braking performance measures between preoperative testing and week 2 postoperatively. Although the lack of a significant change over time in the control group indicates an absence of a significant and substantial practice effect with the driving simulator, the preoperative drive and 2-week postoperative drive may have shown an improvement in some reaction times because of better familiarity with the driving simulator. Patients experienced similar pain levels preoperatively and 2 weeks postoperatively, and thus, it is unlikely that an acute reduction of the patients' preoperative hip pain would explain improved braking performance.

Pain medications may affect driving performance. The participants in the current study refrained from any pain medication usage, the day of his or her driving simulation session. Nonetheless, when making recommendations for return to driving, physicians should counsel patients about the risks of driving while still taking opiate medications.

Limitations

The main limitation of any driving simulator study is that the participants are not driving an actual vehicle, although the simulator provides a safe, experimentally-controlled approach for studying braking performance. We did not test for any left-sided hip arthroscopy procedures and their effect on braking performance; however, a previous study showed

TABLE 3. Medication Use Reported by Experimental Participants

		Postoperative			
	Preoperative, n (%)	2 wks, n (%)	4 wks, n (%)	6 wks, n (%)	8 wks, n (%)
Total n reporting any medication use	4 (29)	10 (71)	5 (36)	5 (36)	3 (21)
No. of medications taking					
1	2 (14)	2 (14)	5 (36)	5 (36)	3 (21)
2	1 (7)	4 (29)	0	0	0
Medication					
Ibuprofen	1 (7)	1 (7)	1 (7)	2 (14)	1 (7)
Percocet	2 (14)	1 (7)	0	0	0
Hydrocodone	1 (7)	1 (7)	0	0	0
Mobic	0	1 (7)	1 (7)	1 (7)	0
Oxycodone	0	3 (21)	2 (14)	1 (7)	1 (7)
Robaxin	0	1 (7)	0	0	0
Tylenol	0	1 (7)	0	0	0
Valium	0	1 (7)	0	0	0
Tramadol	0	0	1 (7)	1 (7)	1 (7)

Percentages (%) represent the percentage of total number of experimental participants (n = 14).

that left-sided total hip arthroplasties have no significant effect.[13]

Another limitation is that the hip arthroscopy procedures in our study differed with respect to the degree of soft tissue and bony surgery. For example, an osteoplasty may affect braking performance much more than a labral debridement. Because of our modest sample size, we were unable to evaluate such differences. Although a larger sample size would have certainly strengthened the study, previously published studies have used similar sized experimental groups when studying return to driving after anterior cruciate ligament reconstruction (12),[14] anterior cervical fusion for disc herniation (12),[15] total hip arthroplasty (25),[13] total knee arthroplasty (18 drivers),[16] and ankle fractures (12).[17]

It is important to note a potential cohort effect in control subjects, as indicated by the significant preexisting differences in objective braking time measurements and self-reported driving history measures, such that this control group may be particularly aggressive in driving, and this is reflected in reaction time outcomes. Future studies should match control subjects to experimental subjects on as many variables as possible with the only difference being right-sided hip pathology and arthroscopy procedure. Finally, driving is a complex task incorporating both physical and neural elements to successfully navigate the road, which should be considered for future work. Ultimately, this study provides some evidence for a safe timeline to driving, but surgeons must still individualize their recommendations for return to driving after right-sided hip arthroscopy procedures.

CONCLUSION

This study's findings suggest that patients may return to driving 2 weeks postoperatively from a right-sided hip arthroscopy procedure.

References

1. Montgomery SR, Ngo SS, Hobson T, et al. Trends and demographics in hip arthroscopy in the United States. *Arthroscopy*. 2013;29:661–665.
2. Hernandez VH, Ong A, Orozco F, et al. When is it safe for patients to drive after right total hip arthroplasty? *J Arthroplasty*. 2015;30:627–630.
3. Ruel A, Lee Y, Boles J, et al. A novel assessment of braking reaction time following THA using a new fully interactive driving simulator. *HSS J*. 2015;11:143–147.
4. Dalury DF, Tucker KK, Kelley TC. When can I drive?: brake response times after contemporary total knee arthroplasty. *Clin Orthop Relat Res*. 2011;469:82–86.
5. Hau R, Csongvay S, Bartlett J. Driving reaction time after right knee arthroscopy. *Knee Surg Sports Traumatol Arthrosc*. 2000;8:89–92.
6. Holt G, Kay M, McGrory R, et al. Emergency brake response time after first metatarsal osteotomy. *J Bone Joint Surg Am*. 2008;90:1660–1664.
7. Egol KA, Sheikhazadeh A, Mogatederi S, et al. Lower-extremity function for driving an automobile after operative treatment of ankle fracture. *J Bone Joint Surg Am*. 2003;85:1185–1189.
8. Marecek GS, Schafer MF. Driving after orthopaedic surgery. *J Am Acad Orthop Surg*. 2013;21:696–706.
9. Bartlett W, Wright W, Masory O. *Driver Abilities in Close Course Testing*. SAE Publication 2000; 2000-01-0179. http://papers.sae.org/2000-01-0179/.
10. Olejnik S, Algina J. Generalized eta and omega squared statistics: measures of effect size for some common research designs. *Psychol Methods*. 2003;8:434–447.
11. Bakeman R. Recommended effect size statistics for repeated measures designs. *Behav Res Methods*. 2005;37:379–384.
12. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale, NJ: Erlbaum; 1988.
13. MacDoland W, Owen JW. The effect of total hip replacement on driving reactions. *J Bone Joint Surg Br*. 1988;70:202–205.
14. Gotlin RS, Sherman AL, Sierra N, et al. Measurement of brake response time after anterior cruciate ligament reconstruction. *Arhtroscopy*. 2000;16:151–155.
15. Lechner R, Thaler M, Krismer M, et al. Driving reaction time before and after cervical fusion for disc herniation: a preliminary study. *Eur Spine J*. 2013;22:1517–1521.
16. Spalding TJ, Kiss J, Kyberd P, et al. Driver reaction times after total knee replacement. *J Bone Joint Surg Br*. 1994;76:754–756.
17. Yousri T, Jackson M. Ankle fractures: when can I drive doctor? A simulation study. *Injury*. 2015;46:399–404.