Purpose: To consolidate the evidence from the available literature and undertake a meta-analysis to provide a reference for physicians to make evidence-based recommendations to their patients regarding the return to driving after hip or knee arthroscopic procedures. Methods: A systematic review was conducted using Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The OVID, Embase, and Cochrane databases were searched through June 2020 for articles containing keywords and/or MeSH (Medical Subject Headings) terms “hip arthroscopy” and “knee arthroscopy” in conjunction with “total brake response time” or “reaction time” in the context of automobile driving. A title review and full article review were performed to assess quality and select relevant articles. A meta-analysis of qualifying articles was undertaken. Results: Eight studies met the inclusion criteria for meta-analysis of brake reaction time (BRT). Meta-analysis of all knee BRTs showed times slower than or equal to baseline BRTs through 5 weeks, with a trend of improving BRTs from 6 to 10 weeks (weeks 8 and 10 were significant, \( P < 0.05 \)). Among all hip BRTs, week 2 showed times slower than baseline BRTs, but after week 4, a trend toward faster BRTs was observed through week 8 (week 8 was significant, \( P < 0.05 \)). Conclusions: BRTs met baseline or control values and continued to improve after 6 weeks after knee arthroscopy and after 4 weeks after hip arthroscopy. On the basis of these results, it would be safe to recommend a return to driving at 6 weeks after knee arthroscopic procedures and 4 weeks after hip arthroscopic procedures. Clinical Relevance: These results can be used by surgeons to base their recommendations on to provide guidance for their patients on the resumption of driving. Although BRT is an important aspect of driving ability, there are additional factors that need to be taken into consideration when making these recommendations, including cessation of opioid analgesics, strength of the surgical limb, and range of motion.

**Hip and knee arthroscopies are some of the most common orthopaedic procedures performed. Studies in the United States have suggested that 70,000 hip arthroscopies are performed annually, with a further 984,607 knees arthroscopies.\(^1\)\(^,\)\(^2\) Such procedures have many advantages over their open-procedure counterparts, such as less postoperative swelling, reduced pain, faster recovery time, and reduced risk of complications. Arthroscopy is available for the treatment of a wide variety of orthopaedic conditions, including anterior cruciate ligament (ACL) reconstruction, meniscectomy, labral repair, femoroacetabular
impingement treatment, and removal of loose bodies, among many others. With patients eager to return to their normal functional level for work, for school, or otherwise, physicians often encounter the question “When can I drive?” at some point in the course of treating of their patients.

Driving involves complex and rapid skill sequences requiring the ability to interact simultaneously with both the vehicle and the external environment. Historically, driving impairment has been described as an increased time needed to perform an emergency stop (often tested as brake reaction time [BRT]); simulations to determine the BRT of a patient after surgery is neither a cost-effective nor practical solution to implement in every clinic or facility that offers arthroscopic surgery. One study found that most physicians recommended that their patients could return to driving after narcotics were discontinued and whenever the patients’ postoperative symptoms would allow for driving. A study on self-regulation of driving found a significant correlation with self-regulation related to driving and the subject’s perception of his or her overall health. However, it was also found that the study participants rated their overall health much higher than expected, suggesting that the patient’s perception of health may not be the most reliable indicator of the ability to return to driving, adding yet another layer of complexity regarding when and how to make recommendations to return to driving for patients after arthroscopic surgery.

The effects of other orthopaedic surgical procedures, such as hip or knee arthroplasty, on the optimal return-to-driving time have also been examined. Whereas the effects of these procedures on driving ability have been better documented, there is a paucity in the literature investigating the effects of hip and knee arthroscopy on driving ability. Among the studies that exist, the recommendations for the optimal time to return to driving are varied.

When making postoperative recommendations for the return to driving, the safety of the patient is paramount. Additionally, there are legal ramifications, as well as the potential of harm to other individuals, that are equally as important to consider when making these recommendations. Previous reviews have combined and presented the results and recommendations from existing studies, but none have completed a meta-analysis of the existing data to search for overarching trends or patterns.

The purpose of this study was to consolidate the evidence from the available literature and undertake a meta-analysis to provide a reference for physicians to make evidence-based recommendations to their patients regarding the return to driving after hip or knee arthroscopic procedures. We hypothesized that driving ability would be adversely affected in the postoperative period after arthroscopic procedures, making a return to driving during this period unsafe for the patient.

**Methods**

**Search Strategy and Selection**

The procedures for this review were developed based on Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines. The OVID, Embase, and Cochrane databases were all used for this systematic review. A brief review of related articles helped to determine the optimal keywords and MeSH (Medical Subject Headings) terms to be used. These terms were incorporated into the search protocol prior to data collection. The search protocol is shown in Appendix Table 1.

**Study Selection**

The inclusion criteria were established following the PICO (population-intervention-comparison-outcomes) approach: The population was defined as adults (age ≥ 18 years) undergoing hip or knee arthroscopy who were able to drive (in possession of a driver’s license). The intervention was defined as hip or knee arthroscopy. The comparator was defined as the preoperative baseline or control cohort. Regarding outcomes, the primary outcome measured was the total brake response time. The secondary outcomes were reaction time, movement time, and braking force.

All studies published prior to July 1, 2020, were considered for eligibility. Table 1 summarizes the inclusion and exclusion criteria used. Titles and abstracts were screened for relevance prior to full inspection. The references of all included studies were reviewed to locate any articles that may have been missed in the database search. Duplicate articles between the databases were removed, and the full texts of all studies meeting the inclusion criteria were obtained.

**Statistical Analysis and Assessment of Methodologic Quality**

Data were extracted from each relevant study and analyzed using RevMan 5.4 (Review Manager, version 5.4; Cochrane, London, England). Means and standard deviations for BRTs were obtained from available study data for meta-analysis. BRTs were compared with preoperative or control values in 3 separate analyses; right (hip or knee) BRTs, left (hip or knee) BRTs, and all (hip or knee) BRTs. Standardized mean differences between preoperative or control BRTs and postoperative BRTs were assessed. When confidence intervals, standard errors, and P values were given in place of standard deviations, standard deviations were imputed using the methods described in the Cochrane Handbook for Systematic Reviews of Interventions (chapter 7.7.3.3).

With varying methodologies and outcome measures, heterogeneity among studies was considered likely, and a random-effects model was used for analysis. In all analyses, P < .05 was considered statistically significant.
results were classed as high risk: 2 studies, low/moderate risk; 2 studies, moderate risk; and 1 study, moderate/high risk. Grading of Recommendations, Assessment, Development and Evaluation (GRADE) analysis (Appendix Table 2) showed the quality of evidence for most of the pooled analyses to be low or very low. On the basis of this, there is a possibility that the true effect may differ significantly from the estimate.

Systematic Review

There were 1,103 patients, with a total of 1,095 remaining after we accounted for loss to follow-up and participant dropout. In the studies that reported the mean age, there was a range of 22 ± 4.61 years 26 to 44 ± 1.14 years.24

Within the existing literature, there was a range of recommendations for optimal return-to-driving time after hip and knee arthroscopic procedures (Fig 2). The most frequent recommendation for the timing of the return to driving was 6 weeks postoperatively, as reported by Cooper29 and Fleury et al.10 after ACL reconstruction (either side) and by Ho and Furlan9 after right-sided ACL reconstruction specifically. This is consistent with recommendations made by Gotlin et al.27 and Nguyen et al.24 based on their prospective experimental studies. Wasserman et al.22 studied the BRTs of 3 different groups based on the type of surgical graft for ACL reconstruction. They, too, recommended waiting 6 weeks to return to driving after hamstring and bone–patellar tendon–bone autograft procedures but recommended waiting only 3 weeks after surgery for tibialis anterior autograft procedures.22 However, these suggestions differ from those of DiSilvestro et al.,11 who recommend a return to driving after ACL reconstruction at 4 weeks postoperatively. Both Hau et al.20

Results

The PRISMA flowchart is shown in Fig 1. After searches of the 3 databases and removal of duplicates, a total of 22 articles were identified. On a full article review, 4 articles were removed because of lack of relevance, abstract-only status, inability to access, and repeat of a previous study. One additional article was found based on a review of references from the previously collected articles. On the basis of the inclusion and exclusion criteria, a total of 19 relevant articles remained. The articles were classified as either prospective cohort, comparative, or case-control studies,14,20-26 repeated-measures designs,27 surveys or questionnaires,6,28,29; literature reviews8-10,28,29; or systematic reviews.11 Of the remaining studies, 8 contained quantitative data on BRTs and were included in the meta-analysis. Table 2 details the characteristics of all included studies.

Methodologic Quality

Table 3 provides an overview of the Critical Appraisal Skills Programme (CASP), MINORS, and Oxford Centre for Evidence-Based Medicine (OCEBM) bias assessments, which were completed for all of the studies included in the meta-analysis. Fourteen studies were graded as low risk: 2 studies, low/modeate risk; 2 studies, moderate risk; and 1 study, moderate/high risk.

Additional studies were included if they met ≥1 of the following inclusion criteria:
- Objective, quantitative measurement such as brake reaction times or related values.
- Qualitative, patient-reported survey data for return to driving.
- Review of current literature focusing on recommendations for return to driving in context of either hip or knee arthroscopic soft-tissue repair.

Studies were excluded if they met ≥1 of the following exclusion criteria:
- Duplicate of previously included study.
- Abstract only.
- Not English-language study.
- Inclusion criteria not met.

Additionally, the $I^2$ value was calculated to measure the heterogeneity of the included studies, indicating the percentage of variation in the meta-analysis caused by heterogeneity rather than chance. An $I^2$ value lower than 30% was considered low heterogeneity, whereas an $I^2$ value greater than 75% was considered high heterogeneity.15

Articles selected for the meta-analysis were critically appraised and examined for bias using the Critical Appraisal Skills Programme (CASP) checklist.16 Each study was graded as having a low, medium, or high risk of bias.

The methodologic quality of the included studies was assessed using the Methodological Index for Non-Randomized Studies (MINORS) index.17 The MINORS index produces a score between 0 and 24, with scores of 0 (not reported), 1 (reported but inadequate), or 2 (reported and adequate) being given for 12 separate factors.17 The score is designed to assess the methodologic quality of nonrandomized surgical studies, whether comparative or noncomparative, with the ideal score being 16 for noncomparative studies and 24 for comparative studies.17 The level of evidence was graded using the Oxford Centre for Evidence-Based Medicine (OCEBM) scale for levels of evidence.18

The overall quality of the evidence in the meta-analysis was assessed using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) system.19 Recommendations were classified as either high (we are very confident that the effect in the study reflects the actual effect), moderate (we are quite confident that the effect in the study is close to the true effect, but it is also possible that it is substantially different), low (the true effect may differ significantly from the estimate), or very low (true effect is probably markedly different from the estimated effect).
and Argintar et al. suggested waiting at least 1 week to drive after simple knee arthroscopy (meniscectomy, chondroplasty, and diagnostic arthroscopy).

In a survey of surgeons performing right knee arthroscopy and their patients, Argintar et al. found that just under 30% of physicians had incorporated guidance on the return to driving during each of the preoperative patient visits. Of the physicians, 57% initiated this conversation half of the time or less frequently and 33.4% initiated this conversation a quarter of the time or less frequently. Most of the physicians surveyed recommended to patients that they could return to driving once pain medications (i.e., opioid analgesics) ceased and when their postoperative symptoms allowed for it. Of the patients surveyed, only 8% stated that their doctor gave them advice regarding returning to driving. When they did receive advice, a large majority (88%) followed the advice they were given. By use of a linear regression model and dummy variables, it was found that patients who were given 2 pieces of advice displayed a longer time to driving than did patients given a only 1 piece of advice. Of note, a study that examined early functional milestones after ACL reconstruction discovered predictors of an earlier return to driving, which included higher age, male sex, and left-sided surgery.

Regarding hip arthroscopy, there was also a varied distribution of recommendations. Vera et al. recommended a return 2 weeks after left hip arthroscopy and 6 weeks after right hip arthroscopy. Momaya et al. similarly recommended a return to driving after 2 weeks but did not differentiate between left- and right-sided surgery. With a recommendation falling in the middle, Balazs et al. recommended returning to driving 4 weeks after hip arthroscopy, also not differentiating by side of surgery. In a survey of patients in 3 different groups based on surgical approach (simultaneous treatment, staged treatment, or single-hip treatment), Mei-Dan et al. found that there was no significant difference in the time after surgery when patients returned to driving. They also noted that the return to daily activities in the bilateral surgery group was similar to that in the unilateral surgery group, “with the advantage of a single rehabilitation.”
Table 2. Characteristics of All Included Studies in Systematic Review

| Study Title                                                                 | Authors                              | Type of Study            | Year Published | Participants, n | Mean Age, yr | Timeline                                                                 | Outcomes                          |
|-----------------------------------------------------------------------------|--------------------------------------|--------------------------|----------------|----------------|----------------|--------------------------------------------------------------------------|-----------------------------------|
| Return to Driving After Hip Arthroscopy                                      | Momaya et al.                        | Prospective study (cohort) | 2018           | 14 (4 participants dropped out) | 27.39 ± 9.13 in surgical group and 28.35 ± 5.81 in control group | The study period was October 2014 to November 2015, with follow-up performed every 2 wk for a total of 8 wk. | Right BRTs                        |
| Evaluation of Driving Skills After Anterior Cruciate Ligament Reconstruction With Hamstring Autograft | Valentí et al.                       | Prospective study (cohort) | 2018           | 62             | 32.39 ± 9.27 in surgical group and 28.58 ± 8.91 in control group | Subjects completed simulated driving and reaction time tests between 4-6 wk postoperatively. | Right and left BRTs               |
| Measurement of Brake Response Time After Right Anterior Cruciate Ligament Reconstruction | Gotlin et al.                        | Prospective repeated-measure design | 2000           | 35             | 31.2 in surgical group and 29.3 in control group | Multiple variables were measured every 2 wk for a total of 10 wk postoperatively. | Right BRTs                         |
| Reaction Time and Brake Pedal Depression Following Arthroscopic Hip Surgery: A Prospective Case-Control Study | Balazs et al.                        | Prospective case-control study | 2018           | 118            | 33.7 in surgical group and 33.3 in control group | BRT and BPD were measured preoperatively and at 2, 4, and 6 wk postoperatively. | Right and left BRTs               |
| Brake Reaction Time After Hip Arthroscopy for Femoroacetabular Impingement and Labral Tear | Vera et al.                          | Prospective comparative study (Level II, diagnostic) | 2017           | 40 (2 participants failed to meet testing time frame and were excluded) | 37.1 ± 12.7 for right knee, 32.1 ± 9.2 for left knee, 35.5 ± 11.1 for right control, and 32.6 ± 8.4 for left control | BRTs and sit-to-stand numbers were measured preoperatively and every 2 wk postoperatively for a total of 8 wk. | Right and left BRTs and sit-to-stand scores |
| Braking Reaction Time After Right-Knee Anterior Cruciate Ligament Reconstruction: A Comparison of 3 Grafts | Wasserman et al.                     | Case-control study       | 2017           | 57             | 29.2 ± 8.2 for HS, 25.0 ± 4.2 for BPTB, 44.0 ± 11.4 for TA, and 30.4 ± 3.8 for control | Thirty healthy volunteers were tested during 1 visit to determine normal mean values, and 27 treatment subjects were tested at 1, 3, and 6 wk after ACL reconstruction. | Right BRTs                         |
| Driving Reaction Time Before and After Anterior Cruciate Ligament Reconstruction | Nguyen et al.                       | Cohort, prospective, comparative study | 2000           | 73             | 30.2 ± 7.9 for right knee, 30.3 ± 8.5 for left knee, and 33.8 ± 10.8 in control group | Each patient underwent driving reaction time and stand tests both preoperatively and at 2, 4, 6, and 8 wk postoperatively. | Right and left BRTs               |

(continued)
Table 2. Continued

| Study Title                                                                 | Authors          | Type of Study                             | Year Published | Participants, n | Mean Age, yr | Timeline                                                                 | Outcomes                                                                 |
|-----------------------------------------------------------------------------|------------------|-------------------------------------------|----------------|-----------------|----------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Driving Reaction Time                                                       | Hau et al. 20     | Cohort, prospective, comparative study    | 2000           | 55              | 42.2 ± 14.2 in surgical group and 33.6 ± 11.0 control              | Each patient was tested both preoperatively and at 1 wk and 4 wk after arthroscopy. | Right BRTs                                                               |
| A Comparative Study of the Neuromuscular Response During a Dynamic Activity | Oliver et al. 26  | Prospective, comparative, matched, controlled study | 2019           | 25 (2 participants later dropped out) | 22 ± 4.61 | Each patient underwent measurement preoperatively and again at 4 and 6 mo postoperatively. | Neuromuscular response of 5 different lower limb muscles                |
| Bilateral Hip Arthroscopy Under the Same Anesthetic for Patients With Symptomatic Bilateral Femoroacetabular Impingement: 1-Year Outcomes | Mei-Dan et al. 31 | Retrospective comparative study            | 2014           | 76              | 33            | Patients were divided into 3 groups based on the approach to hip arthroscopy (simultaneous treatment, staged treatment, or single-hip treatment). | Time (day) of return to various activities and time (day) of cessation of medications |
| Examination of Early Functional Recovery After ACL Reconstruction: Functional Milestone Achievement and Self-Reported Function | Obermeier et al. 30 | Prospective, longitudinal, observational study | 2018           | 182             | 28 ± 12   | Data were collected via survey before surgery as well as 1, 2, 4, 8, and 12 wk after surgery. | SMFA scores, week of return to driving, and week of cessation of pain medication |
| Recommendations for Driving After Right Knee Arthroscopy                    | Argintar et al. 6 | Survey                                    | 2013           | 266 (197 doctors and 69 patients)       | —           | Questionnaires were emailed to surgeons and patients were identified as having undergone knee arthroscopic surgical procedures (including any combination of partial meniscectomy, chondroplasty, or debridement). Any patients undergoing additional ligamentous reconstruction, microfracture, open arthrotenomy, | Frequency of recommendations for postoperative driving, when physicians recommend to return to driving postoperatively, how often patients look at physicians’ advice, when patients look at physicians’ advice, and what policies insurance companies have in place for return |

(continued)
| Study Title                                                                 | Authors            | Type of Study            | Year Published | Participants, n | Mean Age, yr | Timeline                                                                 | Outcomes                                                                 |
|----------------------------------------------------------------------------|--------------------|--------------------------|----------------|-----------------|--------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Knee Arthroscopy and Driving. Results of a Prospective Questionnaire Survey and Review of the Literature | Lewis et al. 28    | Review/prospective questionnaire | 2011           | 100             | —            | Patients were given surveys at their 2-wk follow-up appointment.         | Aspects of consent, when patients returned to driving, and whether patients experienced any adverse events |
| Driving After Orthopaedic Surgery                                          | Marecek and Schafer | Review                   | 2013           | —               | —            | —                                                                        | —                                                                        |
| Resuming Motor Vehicle Driving Following Orthopaedic Surgery or Limb Trauma | Fleury et al. 10   | Review                   | 2012           | —               | —            | —                                                                        | —                                                                        |
| Clinical Decision Making: Doctor, When Can I Drive?                       | Cooper             | Review                   | 2007           | —               | —            | —                                                                        | —                                                                        |
| Driving Following Acute Lower Limb Painful Events                          | Ho and Furlan 9    | Review                   | 2012           | —               | —            | —                                                                        | —                                                                        |
| Driving After Upper or Lower Extremity Orthopaedic Surgery                 | MacKenzie et al. 8 | Review                   | 2019           | —               | —            | —                                                                        | —                                                                        |
| When Can I Drive After Orthopaedic Surgery? A Systematic Review            | DiSilvestro et al. 11 | Systematic review      | 2016           | —               | —            | —                                                                        | —                                                                        |

**NOTE.** A dash indicates data were not available in the study. Age is presented as mean ± standard deviation. ACL, anterior cruciate ligament; BPD, brake pedal depression; BPTB, bone–patellar tendon–bone; BRT, brake reaction time; HS, hamstring; SMFA, Short Musculoskeletal Function Assessment; TA, tibialis anterior.
| Authors | Question 1 | Question 2 | Question 3 | Question 4 | Question 5a/b or Question 6a/b | Results | Precision | Question 7 | Question 8 | Question 9 | Question 10 | Question 11 | Risk of Bias | MINORS Index Score | OCEBM Rating |
|---------|------------|------------|------------|------------|-------------------------------|---------|-----------|------------|------------|------------|------------|------------|-------------|--------------|--------------|
| Obermeier et al. | Yes | Yes | Yes | Yes | Yes/yes | Yes/yes | The results may help clinicians better predict how their patients will recover and could possibly lead to making recommendations to their patients to help them recover more quickly based on these findings. | P < .05 was considered statistically significant. | Yes | Yes | Yes | The results of this study can provide more evidence-based approaches for recommendations for the return to driving after arthroscopy. | Moderate | 17 | 4 |
| Momaya et al. | Yes | Yes | Yes | Yes | Yes/yes | Yes/yes | These data suggest that most patients may return to driving 2 wk after a right-sided hip arthroscopy procedure, as indicated by their braking performance. | P < .05 was considered statistically significant. | Yes | Yes | Yes | This evidence combined with other evidence from other literature can contribute to guidelines regarding the return to driving after hip arthroscopy, particularly between weeks 2-4 of postoperative recovery. | Low | 18 | 3 |
| Valentí et al. | Yes | Yes | Yes | Yes | Yes/yes | Unclear/no | The patients who underwent ACL reconstruction had the same skill and ability as the control group at 4-6 wk after surgery. According to visual reaction times, the driving simulation test in the study, and the available literature, patients who underwent ACL reconstruction with HS grafts and anatomic techniques were able to drive at 4-6 wk after surgery. | P < .05 was considered statistically significant. | Unclear | Yes | Yes | When used in conjunction with other available evidence, this evidence could provide reinforcement to recommending a specific time to return to driving after ACL reconstruction with or without other soft-tissue repair (either right or left leg). | Moderate | 17 | 3 |
| Gotlin et al. | Yes | Yes | Yes | Yes | Yes/yes | Yes/yes | No significant sex differences across main effects were detected. Brake response times for men improved significantly after week 6 (P < .05) and week 10 (P < .01). Brake response times for women in the ACL | P < .05 was considered statistically significant. | Yes | Unclear | Yes | After right ACL reconstruction, patients who participate in an accelerated rehabilitation program can achieve brake response times that are at or near the average of a large database of control subjects by 4-6 wk. | Low | 18 | 3 | (continued)
Table 3. Continued

| Authors         | Question 1 | Question 2 | Question 3 | Question 4 | Question 5a/b or Question 6 | Results | Precision | Question 7 | Question 8 | Question 9 | Question 10 | Question 11 | Risk of Bias | MINORS Index Score | OCEBM Rating |
|-----------------|------------|------------|------------|------------|-----------------------------|---------|-----------|-------------|------------|------------|------------|------------|-------------|---------------|----------------|--------------|
| Vera et al.21    | Yes        | Yes        | Yes        | Yes        | Yes/yes                     | Yes     | Yes       | Unclear     | No         | Yes        | Yes        | Yes/yes    | Yes         | Moderate      | 17            | 3            |
| Nguyen et al.21  | Yes        | Yes        | Yes        | Yes        | Yes/yes                     | Yes     | Yes       | Yes         | Yes        | Yes        | Yes        | Yes        |            | Low           | 18            | 3            |

The evidence could possibly be used in conjunction with other evidence to make recommendations on the return to driving after hip arthroscopy; however, a lack of overall evidence suggests the need for more research on the topic.

This study provides quantitative evidence on which to base recommendations to patients, although the evidence is 20 yr old.
showed a marked decrease after 2 wk and then improved over time but remained slower than that in controls after 8 wk, even though 53.3% of patients had returned to the preoperative level after 6 wk. In the right ACL group, there was a marked decrease in the performance of all tests after 2 wk. Again, the tests improved over time but did not equal those of controls after 8 wk. However, after 6 wk, only 17.5% of patients had returned to their preoperative level via the stepping test; 56.3%, via the standing test; and 75%, via the reaction time test.

Hau et al.\textsuperscript{20} Yes Yes Yes Yes Yes/yes Yes/yes Just over 60% of patients after 1 wk had a slower reaction time than preoperatively. The type of arthroscopic surgery performed did not have an effect on the change in reaction time. At 4 wk postoperatively, the number of steps and stands increased compared with preoperative tests. The average reaction time had also improved (changes were significant). However, 30% of patients tested after

| Authors | Question 1 | Question 2 | Question 3 | Question 4 | Question 5a/b or Question 6a/b | Question 7 | Question 8 | Question 9 | Question 10 | Question 11 | Question 12 | Risk of Bias | MINORS Index Score | OCEBM Rating |
|---------|------------|------------|------------|------------|-------------------------------|------------|------------|------------|------------|------------|------------|-------------|----------------|-------------|
| Hau et al.\textsuperscript{20} | Yes | Yes | Yes | Yes | Yes/yes | Yes/yes | Just over 60% of patients after 1 wk had a slower reaction time than preoperatively. The type of arthroscopic surgery performed did not have an effect on the change in reaction time. At 4 wk postoperatively, the number of steps and stands increased compared with preoperative tests. The average reaction time had also improved (changes were significant). However, 30% of patients tested after | P < .05 was considered statistically significant. | Yes | Yes | Unclear | This study provides quantitative evidence on which to base recommendations to patients, although the evidence is 20 yr old. | Moderate | 17 | 3 |

(continued)
Table 3. Continued

| Authors            | Question 1 | Question 2 | Question 3 | Question 4 | Question 5 or Question 6 | Results                                                                 | Precision | Question 7 | Question 8 | Question 9 | Question 10 | Question 11 | Question 12 | MINORS Index Score | OCEBM Rating |
|--------------------|------------|------------|------------|------------|--------------------------|------------------------------------------------------------------------|-----------|-------------|------------|------------|-------------|-------------|-------------|---------------------|--------------|
| Mei-Dan et al.31   | Yes        | Yes        | No         | Unclear    | Yes/yes                 | 4 wk still had slower reaction times than the preoperative reaction times. The groups were not randomized, some crossover occurred, and more patients elected to undergo simultaneous approaches to hip surgery, which could lead to favoring of the results for that category. | P < .05 was considered statistically significant. | Unclear     | Unclear     | Unclear    | Simultaneous femoroacetabular impingement surgery does not lead to higher rates of complications, postoperative pain, analgesic use, or side effects. The return to daily activities is similar to that of a single-hip procedure with the advantage of a single rehabilitation. | Moderate     | 16          | 3          |
| CASP case control  Oliver et al.26 | Yes        | Yes        | Yes        | Yes        | Yes/yes                 | Comparison of reaction times in the vastus medialis showed that the time for the injured knee was longer preoperatively but it reduced over time, reaching a value at 6 mo postoperatively that was close to the reaction time in the uninjured knee group. In the rectus femoris, biceps femoris, and semitendinosus muscles, the reaction times in the injured knee group were similar to those in the uninjured knee group at the preoperative and postoperative visits. | P < .05 was considered statistically significant. | Yes         | Unclear     | Unclear    | —          | Moderate     | 17          | 4          |
| Balazs et al.13     | Yes        | Yes        | Yes        | Yes        | Yes/yes                 | The results showed that there was a significantly increased BRT in patients undergoing right hip arthroscopy, which reached | P < .05 was considered statistically significant. | Yes         | Yes         | Yes        | —          | Low         | 18          | 3          |

(continued)
| Authors | Question 1 | Question 2 | Question 3 | Question 4 | Question 5a/b or Question 6 | Results | Precision | Question 7 | Question 8 | Question 9 | Question 10 | Question 11 | Question 12 | Risk of Bias | MINORS Index Score | OCEBM Rating |
|---------|------------|------------|------------|------------|----------------------------|---------|-----------|------------|------------|------------|------------|------------|------------|------------|----------------|----------------|
| Wasserman et al. | Yes | Yes | Yes | Yes | Yes/yes | Patients who underwent right knee ACLR with TA allograft regained normal braking times by week 3 postoperatively. In contrast, those treated with BPTB or HS autograft showed significantly delayed braking times at 3 wk but returned to normal braking ability by week 6. Those treated with an autograft had an earlier return of normalized BRT than BTT. | Yes | Yes | Yes | Yes | — | Low | 18 | 4 |
| CASP systematic review | Marecek and Schafer | Yes | Yes | Yes | Yes | — | Relevant sections included the lower-extremity portion on arthroscopy and ACL repair. Patients may anticipate a quick recovery after arthroscopic knee surgery; however, braking function does not return until 4 wk after arthroscopy and 6 wk after right ACL reconstruction. After left ACL reconstruction, patients may drive as early as 2 wk after surgery. However, there is | Yes | Yes | Yes | — | — | Low | — | — |

(continued)
Table 3. Continued

| Authors                  | Question 1 | Question 2 | Question 3 | Question 4 | Question 5 | Question 6 | Question 7 | Question 8 | Question 9 | Question 10 | Question 11 | Question 12 | Risk of Bias | MINORS Index Score | OCEBM Rating |
|--------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|--------------|-------------------|--------------|
| Fleury et al.            | Yes        | Yes        | Yes        | Yes        | Yes        | —          | Yes        | Yes        | Yes        | —          | —          | —          | Low          | —               | —             |
|                          | (continued)|            |            |            |            |            |            |            |            |            |            |            |              |                  |               |
|                          |            |            |            |            |            |            |            |            |            |            |            |            |              |                  |               |
| Cooper                   | Yes        | Yes        | Yes        | Yes        | Yes        | —          | Yes        | Unclear    | Yes        | —          | —          | —          | Low          | —               | —             |
|                          | (continued)|            |            |            |            |            |            |            |            |            |            |            |              |                  |               |
|                          |            |            |            |            |            |            |            |            |            |            |            |            |              |                  |               |
| Ho and Furlan           | Yes        | Yes        | Yes        | Yes        | Yes        | —          | Yes        | Yes        | Yes        | —          | —          | —          | Low          | —               | —             |
|                          | (continued)|            |            |            |            |            |            |            |            |            |            |            |              |                  |               |
|                          |            |            |            |            |            |            |            |            |            |            |            |            |              |                  |               |

significant variability between patients; the step and stand tests may help guide decision making. For knee arthroplasty, the review cited an article comparing 30 surgical subjects with 25 healthy subjects. For most patients, TTB times returned to normal after 4 wk; however, approximately 30% of those patients still had suboptimal TTB times after 1 mo. The authors recommended waiting a minimum of 4 wk to drive after simple knee arthroplasty. After ACL reconstruction, the 2 studies cited both noted TTB times returning to normal after 6 wk, so they recommended waiting at least 6 wk to drive postoperatively. The recommendation after knee arthroscopy was listed as 1 wk, and that after ACL repair was listed as 4-6 wk.

This study consolidates information and recommendations from previous literature and suggests the need for further scientific research that also accounts for other variables, such as...
### Table 3. Continued

| Authors                  | Question 1 | Question 2 | Question 3 | Question 4 | Question 5 or Question 6 | Question 7 | Question 8 | Question 9 | Question 10 | Question 11 | Question 12 | Risk of Bias | MINORS Index Score | OCEBM Rating |
|--------------------------|------------|------------|------------|------------|--------------------------|------------|------------|------------|------------|------------|-------------|---------------|------------------|---------------|
| MacKenzie et al.3        | Yes        | Yes        | Yes        | Yes        | Yes                      | Yes        | Yes        | Yes        | Yes        | Unclear    | Low         | —             | —              | —               |
| DiSilvestro et al.11     | Yes        | Yes        | Yes        | Yes        | Unclear                 | Yes        | Yes        | Yes        | Yes        | Low/unclear| Low/unclear | —             | —              | —               |
| CASP qualitative         | Argintar et al.6 | Yes        | Yes        | Yes        | Yes                      | Yes        | Unclear    | Yes        | This could be useful in encouraging doctors to use more literature and evidence in making their driving recommendations to patient’s post operatively or to bring up the conversation more often. |

During routine preoperative consultation, 29.7% of physicians always incorporated postoperative driving instructions. Of the physicians surveyed, 57% brought up these conversations half of the time or less frequently, 33.4% brought them up one-quarter of the time or less frequently, and 3.1% never discussed this topic. Further subanalysis showed that community-based physicians and physicians who performed >50 knee arthroscopic procedures annually discussed postoperative driving restrictions more commonly. Most physicians recommended driving once narcotic use stopped (70%), when patients believed they could subjectively control their vehicles (57.1%), and when postoperative symptoms allowed.
for safe driving (38.8%). Of the patients surveyed, only 8% received advice from their doctors; of these, 88% followed the advice. Most began driving “when they felt comfortable” around 4-7 d postoperatively. Linear regression found that patients who followed 2 pieces of advice exhibited a longer time to driving than they would have if they had only followed a singular piece of advice from their physicians (e.g., not taking narcotics and/or being comfortable).

Lewis et al.\textsuperscript{28} Yes Yes Unclear Yes No Unclear The authors have illustrated the need for thorough consenting, further research in this area, and the development of universal guidelines surrounding the return to driving after surgery.\textsuperscript{a}

| Authors          | Question 1 | Question 2 | Question 3 | Question 5a/b or Question 6 | Question 7 | Question 8 | Question 9 | Question 10 | Question 11 | Question 12 | Risk of Bias | MINORS Index Score | OCEBM Rating |
|------------------|------------|------------|------------|-----------------------------|------------|------------|------------|------------|-------------|-------------|--------------|-------------------|---------------|
| Lewis et al.\textsuperscript{28} | Yes        | Yes        | Unclear    | Yes                         | No         | Unclear    | Yes        | No         | Yes         | Establishes need for universal guideline for recommendations to return to driving after arthroscopy. | Moderate/high | —             | —               |
Meta-analysis
The demographic characteristics of patients included in the meta-analysis are detailed in Table 4, and the results of each of the included studies are presented in Table 5. In total, 436 patients were included in the meta-analysis, with an age range from 28.6 ± 8.91 years to 44 ± 11.4 years. Of these studies, 5 were cohort studies, 2 were case-control studies, and 1 was a prospective comparative study. BRT data were extracted from all studies, and all data were pooled for analysis. Postoperative BRT data were compared with preoperative BRTs where available and with control group data when preoperative data were not provided.

Knee Arthroscopy
For right knee arthroscopic procedures, collective means for week 1 after surgery showed average BRTs considerably slower than preoperative or control values. Weeks 2 through 10 showed a general trend of decreasing (faster) BRTs, although only weeks 5 and 10 showed statistically significant findings (Fig 3). In the left knee arthroscopy group, weeks 2 through 4 showed BRTs slower than or near baseline values, whereas weeks 6 through 8 showed improved average BRTs compared with preoperative or control values (Fig 4). None of the values were statistically significant. Within the group of combined left and right knee arthroscopies (“all knee BRTs”), BRTs were slower than or near baseline BRTs from week 1 through week 5 postoperatively. There was a trend of improving BRTs from week 6 through week 10, although only weeks 8 and 10 showed statistically significant findings (Fig 5).

Hip Arthroscopy
Within the right hip arthroscopy group, there was a clear trend of improving BRTs, with average BRTs being faster than baseline after week 4 (Fig 6). Left hip arthroscopy mean BRTs showed similar improving trends. Mean BRTs were faster than preoperative or control values after week 6 (Fig 7). Within the right hip group, only week 8 showed significant findings. No values were statistically significant within the left hip arthroscopy group. In the combined left and right hip arthroscopy group (“all hip BRTs”), week 2 showed a mean BRT near baseline values. Weeks 4 through 6 were, on average, faster than baseline, although only week 8 showed statistically significant findings. There was a trend of improving BRTs in the all hip BRT group (Fig 8).

Discussion
This systematic review found variations in the recommendations for the return to driving after both hip and knee arthroscopy procedures. Regarding knee arthroscopy, recommendations ranged from 1 week to 6 weeks and were, in part, dependent on the procedure performed and/or laterality of the procedure. For hip arthroscopy, recommendations ranged from 2 weeks to 6 weeks, again depending on laterality for 1 study. Meta-analysis of all knee BRTs showed that at 6 weeks, the
| Authors        | Year | Procedure                                                                 | No. of Participants | No. of Male Participants | No. of Female Participants | Laterality         | Age, yr | Measured Variables Used in Meta-analysis |
|---------------|------|-----------------------------------------------------------------------------|---------------------|--------------------------|---------------------------|--------------------|---------|-----------------------------------------|
| Nguyen et al. | 2000 | ACL repair                                                                  | 40 (31 surgical and 9 control) | 18                       | 13                        | 16 right and 15 left | 30.2 ± 7.9 for right knee and 30.3 ± 8.5 for left knee | 33.8 ± 10.8 | Right BRT and left BRT |
| Gotlin et al. | 2000 | ACL repair                                                                  | 35 (14 surgical and 21 control) | 12 surgical and 15 control | 15 surgical and 15 control | Right only          | 31.2    | 29.3                                    | Right BRT |
| Hau et al.    | 2000 | Partial meniscectomy, chondroplasty, and diagnostic arthroscopy             | 55 (30 surgical and 25 control) | 9 surgical and 8 control | 21 surgical and 17 control | Right only          | 42.2 ± 14.2 | 33.6 ± 11.0 | Right BRT |
| Wasserman et al. | 2017 | ACL repair                                                                  | 57 (27 surgical and 30 control) | 12 surgical and 15 control | 15 surgical and 15 control | Right only          | 29.2 ± 8.2 for HS, 25.0 ± 4.2 for BPTB, and 44.0 ± 11.4 for TA | 30.4 ± 3.8 | Right BRT |
| Valentí et al. | 2018 | ACL repair                                                                  | 62 (31 surgical and 31 control) | 27 surgical and 22 control | 7 surgical and 9 control | 18 right and 13 left | 32.39 ± 9.27 | 28.58 ± 8.91 | Right BRT and left BRT |
| Vera et al.   | 2017 | Femoroacetabular impingement repair and labral repair                      | 38 (19 surgical and 19 control) | 9 surgical and 9 control | 10 surgical and 10 control | 11 right and 8 left | 37.1 ± 12.7 for right knee and 32.1 ± 9.2 for left knee | 35.5 ± 11.1 for right control and 32.6 ± 8.4 for left control | Right BRT |
| Balazs et al. | 2018 | Femoroacetabular impingement repair                                        | 118 (59 surgical and 59 control) | 32 surgical and 32 control | 27 surgical and 27 control | 33 right and 26 left | 33.7    | 33.3                                    | Right BRT and left BRT |
| Momaya et al. | 2018 | Labral repair, iliopsoas release, osteoplasty, and labral debridement       | 31 (14 surgical and 17 control) | 3 surgical and 4 control | 11 surgical and 13 control | Right only          | 27.39 ± 9.13 | 28.35 ± 5.81 | Right BRT and left BRT |

NOTE. Age is presented as mean ± standard deviation. BPTB, bone–patellar tendon–bone; BRT, brake reaction time; HS, hamstring; TA, tibialis anterior.
Table 5. Summary of All BRT Data From Studies Included in Meta-analysis

| Authors          | Group       | Preoperative | 1 wk  | 2 wk  | 3 wk  | 4 wk  | 5 wk  | 6 wk  | 8 wk  | 10 wk |
|------------------|-------------|--------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Nguyen et al.21  | Right       | 738 ± 198    | 1,503 ± 954 | 805 ± 241 | 733 ± 209 | 686 ± 177 |
|                  | Left        | 662 ± 183    | 660 ± 253 | 625 ± 173 | 589 ± 157 | 595 ± 150 |
|                  | Control     | 694 ± 182    | 590 ± 145 | 590 ± 169 | 587 ± 168 | 578 ± 137 |
| Gotlin et al.27* | Female right| —            | 490    | 470    | 420    | 420    | 430    |
|                  | Male right  | —            | 420    | 390    | 369    | 369    | 377    |
|                  | Female control| —        | 449    | 390    | 410    | 360    | 400    |
|                  | Male control| —            | 450    | 430    | 440    | 435    | 420    |
| Hau et al.20     | Right       | 736 ± 191    | 920 ± 519 | 685 ± 174 |
|                  | Control     | 634 ± 140    | 550 ± 115 | 582 ± 121 |
| Wasserman et al.22| HS         | 970 ± 220    | 800 ± 160 | 730 ± 90 |
|                  | BPTB        | 900 ± 190    | 780 ± 150 | 760 ± 190 |
|                  | TA          | 1,000 ± 240  | 740 ± 140 | 700 ± 140 |
|                  | Control     | 720 ± 90     | 720 ± 90  | 720 ± 90  |
| Valentí et al.24| Right       | 463.9 ± 41.71| 379.04 ± 20.75 | 390.4 ± 31.13 | 330.54 ± 26.9 |
|                  | Left        | 390.4 ± 131  | 330.54 ± 26.9 |
|                  | Control right| 390.4 ± 131  | 330.54 ± 26.9 |
|                  | Control left| 330.54 ± 26.9| 330.54 ± 26.9 |
| Vera et al.23    | Right       | 604 ± 148    | 608 ± 168 | 566 ± 118 | 559 ± 134 | 595 ± 95.5 |
|                  | Left        | 598 ± 121    | 567 ± 143 | 616 ± 178 | 579 ± 162 | 523 ± 87.8 |
|                  | Control right| 516 ± 125    | 516 ± 125 |
|                  | Control left| 504 ± 63.4   | 504 ± 63.4 |
| Balazs et al.14| Right       | 573 (533-616)| 688 (637-743) | 594 (547-645) | 569 (526-615) |
|                  | Left        | 566 (519-616)| 563 (512-618) | 567 (515-623) | 550 (500-604) |
|                  | Control     | 520 (504-536)| 520 (504-536)| 520 (504-536)| 520 (504-536)| 520 (504-536) |
| Momaya et al.25  | Right       | 1,960 ± 180  | 1,840 ± 300 | 1,840 ± 140 | 1,860 ± 250 | 1,860 ± 170 |
|                  | Control     | 1,770 ± 180  | 1,720 ± 170 | 1,720 ± 170 | 1,670 ± 270 | 1,690 ± 260 |

NOTE. Data are presented as mean ± standard deviation unless otherwise indicated. BPTB, bone–patellar tendon–bone; BRT, brake reaction time; HS, hamstring; TA, tibialis anterior.

*No preoperative values were reported; postoperative BRTs were compared with control values.

†All procedures were right sided; groups were categorized by the type of ligament used for reconstruction.

‡Postoperative BRTs were collected between weeks 4 and 6.

§Data are reported as mean (confidence interval).
pooled means had met or become faster than the preoperative or control values, and there was a trend of improving BRTs after this point. Side-specific analysis revealed similar findings (patients were able to return more quickly to driving after left knee arthroscopy, but these findings were not statistically significant), with pooled means showing improved BRTs after 6 weeks, as well as a trend of improvement in the right-sided group through week 10. Meta-analysis of all hip BRTs showed that pooled means had met or become faster than preoperative or control times at 4 weeks, with a trend of improving BRTs. It is interesting to note that side-specific analysis revealed that pooled means for right-sided procedures were faster than preoperative or control BRTs at 4 weeks whereas pooled means for left-sided procedures just met baseline values at 4 weeks. These findings are notable because a meta-analysis had not been performed on this subject previously, although the small data pool does suggest the need for further research to expand the pool for future meta-analysis.

When assessing BRT, patients’ values in most studies included in the meta-analysis were compared with their preoperative values. This assumes that the patient was driving safely prior to the surgical procedure. However, a patient presenting with the need for arthroscopy presumably has an underlying pathology that requires

Fig 3. Pooled data and forest plot of right knee arthroscopy brake reaction times. $P < .05$ is considered statistically significant. It should be noted that Valentí et al.$^{24}$ reported brake reaction times between 4 and 6 weeks postoperatively. These data were averaged to “week 5” for the purposes of analysis and plotting data. (CI, confidence interval; IV, inverse-variance method; Post-op, postoperative; Pre-op, preoperative; SD, standard deviation; Std, standardized.)

| Study or Subgroup | Post-op Mean | Post-op SD | Pre-op Mean | Pre-op SD | Std. Mean Difference IV, Random, 95% CI | Std. Mean Difference IV, Random, 95% CI |
|-------------------|--------------|------------|-------------|-----------|-----------------------------------|-----------------------------------|
| 1.1.1 Week 1 | | | | | | |
| Hsu 2000 | 0.92 | 0.519 | 30 | 0.736 | 0.191 | 30 | 51.7% | 0.46 [-0.05, 0.98] |
| Wasserman 2017 | 0.956571 | 0.216645 | 21 | 0.72 | 0.09 | 30 | 48.3% | 1.51 [0.87, 2.14] |
| Subtotal (95% CI) | 51 | 60 | 100.0% | 0.97 [-0.05, 1.99] |
| Heterogeneity: $\tau^2 = 0.45$; $\chi^2 = 6.24$, df = 1 ($P = 0.01$); $I^2 = 84$
| Test for overall effect: $Z = 1.86$ ($P = 0.06$) |
| 1.1.2 Week 2 | | | | | | |
| Gottlin 2000 | 0.466639 | 0.0186788 | 14 | 0.449751 | 0.0186788 | 21 | 50.3% | -0.69 [-1.18, 0.11] |
| Nguyen 2000 | 1.503 | 0.954 | 16 | 0.738 | 0.198 | 16 | 49.7% | 1.08 [0.33, 1.83] |
| Subtotal (95% CI) | 30 | 37 | 100.0% | 0.19 [-1.54, 1.93] |
| Heterogeneity: $\tau^2 = 1.43$; $\chi^2 = 11.47$, df = 1 ($P = 0.0007$); $I^2 = 91$
| Test for overall effect: $Z = 0.22$ ($P = 0.83$) |
| 1.1.3 Week 3 | | | | | | |
| Wasser 2017 | 0.773256 | 0.149985 | 21 | 0.72 | 0.09 | 30 | 100.0% | 0.44 [-0.12, 1.01] |
| Subtotal (95% CI) | 21 | 30 | 100.0% | 0.44 [-0.12, 1.01] |
| Heterogeneity: Not applicable
| Test for overall effect: $Z = 1.54$ ($P = 0.12$) |
| 1.1.4 Week 4 | | | | | | |
| Gottlin 2000 | 0.410807 | 0.0031412 | 14 | 0.413012 | 0.0031412 | 21 | 52.4% | -0.69 [-1.38, 0.01] |
| Hsu 2000 | 0.685 | 0.174 | 30 | 0.736 | 0.191 | 30 | 55.9% | -0.28 [-0.78, 0.23] |
| Nguyen 2000 | 0.954 | 0.241 | 16 | 0.738 | 0.198 | 16 | 31.7% | 0.95 [0.22, 1.69] |
| Subtotal (95% CI) | 60 | 67 | 100.0% | -0.02 [-0.89, 0.85] |
| Heterogeneity: $\tau^2 = 0.48$; $\chi^2 = 11.04$, df = 2 ($P = 0.004$); $I^2 = 82$
| Test for overall effect: $Z = 0.04$ ($P = 0.97$) |
| 1.1.5 Week 5 | | | | | | |
| Valentí 2018 | 0.4639 | 0.04171 | 18 | 0.3904 | 0.03113 | 18 | 100.0% | 1.95 [1.14, 2.76] |
| Subtotal (95% CI) | 18 | 18 | 100.0% | 1.95 [1.14, 2.76] |
| Heterogeneity: Not applicable
| Test for overall effect: $Z = 4.73$ ($P < 0.00001$) |
| 1.1.6 Week 6 | | | | | | |
| Gottlin 2000 | 0.379869 | 0.067576 | 14 | 0.427306 | 0.067576 | 21 | 30.0% | -0.69 [-1.38, 0.01] |
| Nguyen 2000 | 0.733 | 0.209 | 16 | 0.738 | 0.198 | 16 | 30.3% | -0.02 [-0.72, 0.67] |
| Wasserman 2017 | 0.722972 | 0.139986 | 21 | 0.72 | 0.09 | 30 | 39.8% | 0.09 [-0.47, 0.64] |
| Subtotal (95% CI) | 51 | 67 | 100.0% | -0.18 [-0.64, 0.32] |
| Heterogeneity: $\tau^2 = 0.06$; $\chi^2 = 1.08$, df = 2 ($P = 0.21$); $I^2 = 35$
| Test for overall effect: $Z = 0.76$ ($P = 0.45$) |
| 1.1.7 Week 8 | | | | | | |
| Gottlin 2000 | 0.379869 | 0.0329499 | 14 | 0.402999 | 0.0329499 | 21 | 49.9% | -0.69 [-1.38, 0.01] |
| Nguyen 2000 | 0.686 | 0.177 | 16 | 0.738 | 0.198 | 16 | 50.1% | -0.27 [-0.97, 0.43] |
| Subtotal (95% CI) | 30 | 37 | 100.0% | -0.48 [-0.97, 0.02] |
| Heterogeneity: $\tau^2 = 0.00$; $\chi^2 = 0.68$, df = 1 ($P = 0.41$); $I^2 = 0$
| Test for overall effect: $Z = 1.90$ ($P = 0.06$) |
| 1.1.8 Week 10 | | | | | | |
| Gottlin 2017 | 0.376587 | 0.0620706 | 14 | 0.420159 | 0.0620706 | 21 | 100.0% | -0.69 [-1.38, 0.01] |
| Subtotal (95% CI) | 14 | 21 | 100.0% | -0.69 [-1.38, 0.01] |
| Heterogeneity: Not applicable
| Test for overall effect: $Z = 1.93$ ($P = 0.05$) |
The presence of this pathology before surgery could lead to not only slower baseline BRTs but also a decreased ability to drive safely. In this instance, it would be difficult to determine, using BRT alone, whether a patient is able to safely return to driving after surgery. Future studies on BRTs might consider comparing postoperative BRTs with both preoperative values and the corresponding values of a healthy control group.

Both the study by Nguyen et al.21 and the study by Hau et al.20 had their participants perform sit-to-stand tests in the office and found that there was a significant correlation between performance on sit-to-stand testing and BRTs. This test potentially could be performed during follow-up appointments by surgical patients to assess their readiness to drive. Although BRT is a very important factor to be considered when making recommendations on the resumption of driving, many studies have noted the significance of factoring in other variables, such as cessation of opioid analgesics, strength of the surgical limb, and range of motion.11

An interesting consideration related to both preoperative and postoperative driving ability is joint proprioception, particularly related to knee arthroscopy and ACL reconstruction. The ACL itself helps with proprioception of the knee joint, containing many mechanoreceptors that respond to mechanical stimulation and help determine where one’s limb is in space. Damage to the ACL before surgery leads to a decrease in proprioceptive ability not only in the surgical knee but also in the contralateral knee, as noted by previous studies.32-34 If a patient continues driving, this could lead to an impaired driving ability and slower BRTs preoperatively. However, it is also important to note that reconstruction of the ACL does not lead to an immediate return of proprioceptive ability. Extensive and consistent physical therapy and kinesthetic exercises are needed to allow for the return of proprioceptive ability.32-34 Additionally, because autografts (e.g., hamstring or patellar tendon) use tissue from the patients themselves, damage to the donor tissue could lead to a further decrease in proprioceptive ability.35

The type of surgical procedure also appeared to be related to the recommended resumption of driving. Studies that exclusively examined ACL reconstruction recommended resumption of driving at 6 weeks or between 4 and 6 weeks.21,22,24,27 Studies that examined simple knee arthroscopy, such as those of Hau et al.20 and Argintar et al.,6 gave much earlier recommendations on the resumption of driving (approximately 1 week). This finding highlights that there is a clear difference between knee ligamentous and non-ligamentous surgery and advice should be given to patients accordingly.

| Study or Subgroup | Post-op Mean (SD) | Total | Pre-op Mean (SD) | Total | Std. Mean Difference IV, Random, 95% CI | Std. Mean Difference IV, Random, 95% CI |
|-------------------|-------------------|-------|------------------|-------|----------------------------------------|----------------------------------------|
| 2.1.1 Week 2      |                   |       |                  |       |                                        |                                        |
| Nguyen 2000       | 0.66 (0.253)      | 15    | 0.662 (0.183)    | 15    | -0.01 [-0.72, 0.71]                    | 0.01 [-0.72, 0.71]                     |
| Subtotal (95% CI) |                   | 15    |                  | 15    |                                        |                                        |
| Heterogeneity: Not applicable | |       |                  |       |                                        |                                        |
| Test for overall effect: Z = 0.02 (P = 0.98) | |       |                  |       |                                        |                                        |
| 2.1.2 Week 4      |                   |       |                  |       |                                        |                                        |
| Nguyen 2000       | 0.625 (0.157)     | 15    | 0.662 (0.183)    | 15    | -0.21 [-0.93, 0.51]                    | 0.21 [-0.93, 0.51]                     |
| Subtotal (95% CI) |                   | 15    |                  | 15    |                                        |                                        |
| Heterogeneity: Not applicable | |       |                  |       |                                        |                                        |
| Test for overall effect: Z = 0.58 (P = 0.56) | |       |                  |       |                                        |                                        |
| 2.1.3 Week 5      |                   |       |                  |       |                                        |                                        |
| Valent 2018       | 0.37904 (0.02075) | 13    | 0.33054 (0.0269) | 13    | 1.96 [0.99, 2.92]                      | 1.96 [0.99, 2.92]                      |
| Subtotal (95% CI) |                   | 13    |                  | 13    |                                        |                                        |
| Heterogeneity: Not applicable | |       |                  |       |                                        |                                        |
| Test for overall effect: Z = 3.99 (P < 0.0001) | |       |                  |       |                                        |                                        |
| 2.1.5 Week 6      |                   |       |                  |       |                                        |                                        |
| Nguyen 2000       | 0.589 (0.157)     | 15    | 0.662 (0.183)    | 15    | -0.42 [-1.14, 0.31]                    | -0.42 [-1.14, 0.31]                    |
| Subtotal (95% CI) |                   | 15    |                  | 15    |                                        |                                        |
| Heterogeneity: Not applicable | |       |                  |       |                                        |                                        |
| Test for overall effect: Z = 1.13 (P = 0.26) | |       |                  |       |                                        |                                        |
| 2.1.6 Week 8      |                   |       |                  |       |                                        |                                        |
| Nguyen 2000       | 0.595 (0.15)      | 15    | 0.662 (0.183)    | 15    | -0.39 [-1.11, 0.33]                    | -0.39 [-1.11, 0.33]                    |
| Subtotal (95% CI) |                   | 15    |                  | 15    |                                        |                                        |
| Heterogeneity: Not applicable | |       |                  |       |                                        |                                        |
| Test for overall effect: Z = 1.06 (P = 0.29) | |       |                  |       |                                        |                                        |

Test for subgroup differences: Chi² = 18.60, df = 4 (P = 0.0009), I² = 78.5%

Fig 4. Pooled data and forest plot of left knee arthroscopy brake reaction times. P < .05 is considered statistically significant. It should be noted that Valentí et al.24 reported brake reaction times between 4 and 6 weeks postoperatively. These data were averaged to “week 5” for the purposes of analysis and plotting data. (CI, confidence interval; IV, inverse-variance method; Post-op, postoperative; Pre-op, preoperative; SD, standard deviation; Std, standardized.)
reconstruction, the specific type of graft had a correlation with when postoperative BRTs met baseline values. On the basis of their results, they recommended resumption of driving at 6 weeks postoperatively after hamstring and bone-patellar tendon–bone autograft procedures and at 3 weeks postoperatively after tibialis anterior allograft procedures.22 This provides an additional starting point for future research to explore more deeply.

Limitations
One notable limitation of this study was the small existing data pool from a limited number of studies. There is limited existing research regarding the resumption of driving after arthroscopic procedures specifically. Additionally, among the few available studies, there is considerable heterogeneity of data. For instance, the effect of ACL reconstruction on BRTs may not be comparable to the effect of meniscal repair or diagnostic arthroscopy on BRTs. Should the effects on BRTs be separated by type of procedure, given sufficient data, there may be different outcomes and, therefore, different recommendations than those noted in this article. There were also slight methodologic differences between studies, as well as varied outcome measures.

Fig 5. Pooled data and forest plot of all knee arthroscopy brake reaction times. *P < .05 is considered statistically significant. It should be noted that Valentí et al.24 reported brake reaction times between 4 and 6 weeks postoperatively. These data were averaged to “week 5” for the purposes of analysis and plotting data. (CI, confidence interval; IV, inverse-variance method; Post-op, postoperative; Pre-op, preoperative; SD, standard deviation; Std, standardized.)
An example of this is highlighted by the study of Valentí et al., which collected BRTs between 4 and 6 weeks postoperatively, as opposed to collecting them each week (week 4, week 5, and week 6) as other studies did. This proved to be a challenge when incorporating these data for comparison with data from other studies.

Fig 6. Pooled data and forest plot of right hip arthroscopy brake reaction times. $P < .05$ is considered statistically significant. (CI, confidence interval; IV, inverse-variance method; Post-op, postoperative; Pre-op, preoperative; SD, standard deviation; Std, standardized.)

| Study or Subgroup | Post-op Mean | SD | Total | Pre-op Mean | SD | Total | Weight | IV, Random, 95% CI | Year |
|-------------------|-------------|----|-------|-------------|----|-------|--------|-----------------|------|
| **3.1.2 Week 2** |             |    |       |             |    |       |        |                 |      |
| Vera 2017         | 0.608       | 0.168 | 11    | 0.604       | 0.148 | 11    | 29.2%  | 0.02 [-0.61, 0.86] | 2017 |
| Balazs 2018       | 0.688       | 0.196 | 36    | 0.573       | 0.1265 | 36    | 35.6%  | 0.81 [0.33, 1.29]  | 2018 |
| Momaya 2018       | 1.84        | 0.3   | 31    | 1.96        | 0.18  | 31    | 35.2%  | -0.48 [-0.98, 0.03] | 2018 |
| Subtotal (95% CI) | 78          |     |       | 78          |     |       | 100.0% | 0.13 [-0.74, 1.00]  |      |

Heterogeneity: $I^2 = 49$; $Q = 13.21$; $df = 2$ ($p = 0.001$); $I^2 = 85$
Test for overall effect: $Z = 0.29$ ($p = 0.78$)

| Study or Subgroup | Post-op Mean | SD | Total | Pre-op Mean | SD | Total | Weight | IV, Random, 95% CI | Year |
|-------------------|-------------|----|-------|-------------|----|-------|--------|-----------------|------|
| **3.1.4 Week 4**  |             |    |       |             |    |       |        |                 |      |
| Vera 2017         | 0.566       | 0.118 | 11    | 0.604       | 0.148 | 11    | 25.2%  | -0.27 [-1.11, 0.57] | 2017 |
| Balazs 2018       | 0.594       | 0.1448 | 36    | 0.573       | 0.1265 | 36    | 38.5%  | 0.16 [-0.31, 0.62] | 2018 |
| Momaya 2018       | 1.84        | 0.14  | 31    | 1.96        | 0.18  | 31    | 36.4%  | -0.73 [-1.25, -0.22] | 2018 |
| Subtotal (95% CI) | 78          |     |       | 78          |     |       | 100.0% | -0.28 [-0.88, 0.32] |      |

Heterogeneity: $I^2 = 19$; $Q = 6.34$; $df = 2$ ($p = 0.04$); $I^2 = 60$
Test for overall effect: $Z = 0.90$ ($p = 0.37$)

| Study or Subgroup | Post-op Mean | SD | Total | Pre-op Mean | SD | Total | Weight | IV, Random, 95% CI | Year |
|-------------------|-------------|----|-------|-------------|----|-------|--------|-----------------|------|
| **3.1.5 Week 6**  |             |    |       |             |    |       |        |                 |      |
| Vera 2017         | 0.559       | 0.134 | 11    | 0.604       | 0.148 | 11    | 14.1%  | -0.31 [-1.15, 0.54] | 2017 |
| Balazs 2018       | 0.569       | 0.13152 | 36    | 0.573      | 0.1265 | 36    | 46.7%  | 0.06 [-0.49, 0.58] | 2018 |
| Momaya 2018       | 1.86        | 0.25  | 31    | 1.96        | 0.18  | 31    | 39.9%  | -0.45 [-0.96, 0.05] | 2018 |
| Subtotal (95% CI) | 78          |     |       | 78          |     |       | 100.0% | -0.24 [-0.55, 0.08] |      |

Heterogeneity: $I^2 = 0.00$; $Q = 1.49$; $df = 2$ ($p = 0.79$); $I^2 = 0$
Test for overall effect: $Z = 1.46$ ($p = 0.14$)

| Study or Subgroup | Post-op Mean | SD | Total | Pre-op Mean | SD | Total | Weight | IV, Random, 95% CI | Year |
|-------------------|-------------|----|-------|-------------|----|-------|--------|-----------------|------|
| **3.1.6 Week 8**  |             |    |       |             |    |       |        |                 |      |
| Vera 2017         | 0.595       | 0.0955 | 11    | 0.604       | 0.148 | 11    | 27.0%  | -0.07 [-0.91, 0.71] | 2017 |
| Momaya 2018       | 1.86        | 0.17  | 31    | 1.96        | 0.18  | 31    | 73.0%  | -0.56 [-1.07, -0.06] | 2018 |
| Subtotal (95% CI) | 42          |     |       | 42          |     |       | 100.0% | -0.43 [-0.86, 0.00] |      |

Heterogeneity: $I^2 = 0.00$; $Q = 0.98$; $df = 1$ ($p = 0.32$); $I^2 = 0$
Test for overall effect: $Z = 1.94$ ($p = 0.05$)

Test for subgroup differences: $I^2 = 1.37$; $df = 3$ ($p = 0.71$); $I^2 = 0$

Fig 6. Pooled data and forest plot of right hip arthroscopy brake reaction times. $P < .05$ is considered statistically significant. (CI, confidence interval; IV, inverse-variance method; Post-op, postoperative; Pre-op, preoperative; SD, standard deviation; Std, standardized.)

Fig 7. Pooled data and forest plot of left hip arthroscopy brake reaction times. $P < .05$ is considered statistically significant. (CI, confidence interval; IV, inverse-variance method; Post-op, postoperative; Pre-op, preoperative; SD, standard deviation; Std, standardized.)
as the data of Valentí et al. had to be averaged to “week 5” for the purposes of plotting and statistical analysis. Because of this larger time frame for BRTs, the data could appear skewed: BRTs taken closer to the 4-week mark would appear faster than in actuality, whereas BRTs measured closer to the 6-week mark would appear slower than in actuality.

Our study also suggests the need for further research to expand the available data pool. Further research could more extensively explore BRT differences based on the side of surgery or type of surgical procedure, investigate the effects of non-modifiable factors such as sex and age, or consider additional measures of driving performance.

Conclusions

BRTs met baseline or control values and continued to improve after 6 weeks after knee arthroscopy and after 4 weeks after hip arthroscopy. On the basis of these results, it would be safe to recommend a return to driving at 6 weeks after knee arthroscopic procedures and 4 weeks after hip arthroscopic procedures.

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### Appendix Table 1. OVID, Embase, and Cochrane Database Search Protocols With Numbers of Results Identified From Search Strategy

| Search                                                                 | No. of Results |
|-----------------------------------------------------------------------|----------------|
| **OVID**                                                              |                |
| 1. “Knee arthroscopy” or “Hip arthroscopy” or “arthroscopic knee surgery” or “arthroscopic hip surgery” or “anterior cruciate ligament surgery” or “anterior cruciate ligament reconstruction” or “posterior cruciate ligament repair” or “posterior cruciate ligament reconstruction” or “medial patellofemoral ligament repair” or “medial collateral ligament repair” or “lateral collateral ligament repair” or “knee soft tissue repair” or “hip soft tissue repair” or “soft tissue injury” or “joint loose body” or “fibrocartilage” or “arthroscopy” or “arthroscopy rehabilitation” or “Femoroacetabular Impingement repair” or “Labral tear repair” or “chondroplasty” or “microfracture” or “synovectomy” or “Osteochondral Autograft Transfer System” or “mosaicplasty” | 46,003         |
| 2. “total brake response time” or “reaction time” or “moving time” or “movement time” or “recovery of function” | 171,452        |
| 3. “driving reaction” or “driving skill” or “driving ability” or “driving” | 97,430         |
| 4. 2 or 3                                                             | 266,893        |
| 5. 1 and 4                                                            | 2,042          |
| 6. Limit 5 to English Language Articles                                | 1,945          |
| 7. Exp Automobile Driving                                              | 183            |
| 8. 5 and 7                                                            | 149            |
| **Embase**                                                            |                |
| 1. “Knee arthroscopy” or “Hip arthroscopy” or “arthroscopic knee surgery” or “arthroscopic hip surgery” or “anterior cruciate ligament surgery” or “anterior cruciate ligament reconstruction” or “posterior cruciate ligament repair” or “posterior cruciate ligament reconstruction” or “medial patellofemoral ligament repair” or “medial collateral ligament repair” or “lateral collateral ligament repair” or “knee soft tissue repair” or “hip soft tissue repair” or “soft tissue injury” or “joint loose body” or “fibrocartilage” or “arthroscopy” or “arthroscopy rehabilitation” or “Femoroacetabular Impingement repair” or “Labral tear repair” or “chondroplasty” or “microfracture” or “synovectomy” or “Osteochondral Autograft Transfer System” or “mosaicplasty” | 40,342         |
| 2. “total brake response time” or “reaction time” or “moving time” or “movement time” or “recovery of function” | 119,340        |
| 3. “driving reaction” or “driving skill” or “driving ability” or “driving” | 118,400        |
| 4. 2 or 3                                                             | 235,595        |
| 5. 1 and 4                                                            | 135            |
| 6. Limit to English Language Articles                                  | 130            |
| **Cochrane**                                                          |                |
| 1. (“Knee arthroscopy” or “Hip arthroscopy” or “arthroscopic knee surgery” or “arthroscopic hip surgery” or “anterior cruciate ligament surgery” or “anterior cruciate ligament reconstruction” or “posterior cruciate ligament repair” or “posterior cruciate ligament reconstruction” or “medial patellofemoral ligament repair” or “medial collateral ligament repair” or “lateral collateral ligament repair” or “knee soft tissue repair” or “hip soft tissue repair” or “soft tissue injury” or “joint loose body” or “fibrocartilage” or “arthroscopy” or “arthroscopy rehabilitation” or “Femoroacetabular Impingement repair” or “Labral tear repair” or “chondroplasty” or “microfracture” or “synovectomy” or “Osteochondral Autograft Transfer System” or “mosaicplasty”) | 5,593          |
| 2. [AND] “total brake response time” or “reaction time” or “moving time” or “movement time” or “recovery of function” or “driving reaction” or “driving skill” or “driving ability” or “return to driving” or “returned to driving” | 17,352         |
| 3. [AND] Automobile driving                                            | 814            |
| 4. 1, 2, and 3                                                        | 9              |
| Meta-analysis | Time Point of Subanalysis | Standardized Mean Difference | Confidence Interval | Design (0-2) | Inconsistency (0-1) | Indirectness (0-1) | Imprecision (0-1) | Publication Bias (0-1) | Overall Quality (0-9)* |
|---------------|--------------------------|-----------------------------|---------------------|-------------|-------------------|-------------------|------------------|----------------------|----------------------|
| Knee arthroscopy |                          |                             |                     |             |                   |                   |                  |                      |                      |
| TBRT right    | 1 wk                     | 0.97                        | -0.05 to 1.99       | Low (-2)     | Moderate (-1)     | Yes (-1)          | No                | Yes (-1)          | Yes (-1)             | Very low (3)         |
|               | 2 wk                     | 0.19                        | -1.54 to 1.93       | Low (-2)     | Moderate (-1)     | Yes (-1)          | No                | Yes (-1)          | Yes (-1)             | Very low (3)         |
|               | 3 wk                     | 0.44                        | -0.12 to 1.01       | Low (-2)     | Moderate (-1)     | NA                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 4 wk                     | -0.02                       | -0.89 to 0.85       | Low (-2)     | Moderate (-1)     | Yes (-1)          | No                | Yes (-1)          | Yes (-1)             | Very low (3)         |
|               | 5 wk                     | 1.95                        | 1.14 to 2.76        | Low (-2)     | Moderate (-1)     | NA                | No                | No                | Yes (-1)             | Low (4)              |
|               | 6 wk                     | -0.18                       | -0.64 to 0.28       | Low (-2)     | Moderate (-1)     | No                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 8 wk                     | -0.48                       | -0.97 to 0.02       | Low (-2)     | Moderate (-1)     | No                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 10 wk                    | -0.69                       | -1.38 to 0.01       | Low (-2)     | Moderate (-1)     | NA                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               |                          |                             |                     |             |                   |                   |                  |                      |                      |
| TBRT left     | 2 wk                     | -0.01                       | -0.72 to 0.71       | Low (-2)     | Moderate (-1)     | NA                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 4 wk                     | -0.21                       | -0.93 to 0.51       | Low (-2)     | Moderate (-1)     | NA                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 5 wk                     | 1.96                        | 0.99 to 2.92        | Low (-2)     | Moderate (-1)     | NA                | No                | No                | Yes (-1)             | Low (5)              |
|               | 6 wk                     | -0.42                       | -1.14 to 0.31       | Low (-2)     | Moderate (-1)     | NA                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 8 wk                     | -0.39                       | -1.11 to 0.33       | Low (-2)     | Moderate (-1)     | NA                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
| Hip arthroscopy |                          |                             |                     |             |                   |                   |                  |                      |                      |
| TBRT right    | 2 wk                     | 0.13                        | -0.74 to 1.00       | Low (-2)     | Moderate (-1)     | Yes (-1)          | No                | Yes (-1)          | Yes (-1)             | Very low (3)         |
|               | 4 wk                     | -0.28                       | -0.88 to 0.32       | Low (-2)     | Moderate (-1)     | Yes (-1)          | No                | Yes (-1)          | Yes (-1)             | Very low (3)         |
|               | 6 wk                     | -0.24                       | -0.55 to 0.08       | Low (-2)     | Moderate (-1)     | No                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 8 wk                     | -0.43                       | -0.86 to 0.00       | Low (-2)     | Moderate (-1)     | No                | No                | No                | Yes (-1)             | Low (5)              |
|               |                          |                             |                     |             |                   |                   |                  |                      |                      |
| TBRT left     | 2 wk                     | -0.07                       | -0.55 to 0.41       | Low (-2)     | Moderate (-1)     | No                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 4 wk                     | 0.03                        | -0.44 to 0.51       | Low (-2)     | Moderate (-1)     | No                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 6 wk                     | -0.13                       | -0.60 to 0.35       | Low (-2)     | Moderate (-1)     | No                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |
|               | 8 wk                     | -0.67                       | -1.69 to 0.35       | Low (-2)     | Moderate (-1)     | NA                | No                | Yes (-1)          | Yes (-1)             | Low (4)              |

NA, not applicable; RCT, randomised controlled trial; TBRT, total brake reaction time.

*Overall quality was rated as very low for scores of 0 to 3; low, 4 to 5; moderate, 6 to 7; or high, 8 to 9.