REVIEW

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Prognostic Pre-Operative Factor Influencing Hip Arthroscopy Outcomes for Femoroacetabular Impingement Syndrome: a Comprehensive Literature Review

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ABBREVIATIONS:
HA: hip arthroscopy
FAIS: femoroacetabular impingement syndrome
PROMs: Patients Reported Outcome Measurements
THA: total hip arthroplasty
ROM: range of motion
mHHS: modified Harris Hip scores
NAHS: non-arthritic hip score
(HOS-SSS): hip outcome score-sport specific subscale
RCT: randomized controlled trial
AO: osteoarthrosis
BMI: body mass index
PDS: preoperative duration of symptoms

SUMMARY

Introduction. The number of hip arthroscopies (HAs) have been greatly increased in the last fifteen years parallel to the diffusion of the knowledge of femoroacetabular impingement syndrome (FAIS). Unfortunately, outcomes of HA can be variable and not always satisfactory. The recognition of pre-operative factors which may negatively affect the outcomes of FAIS arthroscopic treatment is therefore of primary importance. The purpose of this review article is to identify those factors.

Methods. This review was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Three databases (PubMed, Google Scholar, EMBASE) were searched using the following key words: "femur acetabular impingement", "hip arthroscopy", "outcome". Studies were screened and data extracted in duplicate.

Results. Different pre-operative factors can negatively influence the clinical outcomes of HA for FAIS: older age, chondral injury, gender, bone cyst and subchondral edema, osteoarthritis, low preoperative Patients Reported Outcome Measurements (PROMs), long duration of symptoms and surgeon experience.

Conclusions. Hip Arthroscopy is an established surgical technique for the treatment of FAIS. Surgeons and Patients should be aware about the negative pre-operative prognostic factors before the procedure.

KEY WORDS

Hip arthroscopy; femoroacetabular impingement syndrome; outcome; predictors; PROMs; cam; pincer.

INTRODUCTION

The number of hip arthroscopies (HAs) preformed increased exponentially in the last fifteen years due to numerous studies and better comprehension of the hip biomechanics and pathology. Different articles demonstrate the effectiveness of HA for the treatment of femoroacetabular impingement syndrome (FAIS) (1-3). However, some patients still show unsatisfactory results, requiring a second arthroscopy or a total hip replacement (4). Predictors of outcome after HA for FAIS are currently under investigation. Clinical failure of primary HA was defined as revision hip arthroscopy or conversion to total hip arthroplasty (THA) rate (4), which range from 1% to 50% according to different authors (5-7). In their systematic review of the literature, including more than 6000 patients, Harris *et al.* (8) found that the reoperation rate was 6.3% at a mean 16 months follow-up, and that conversion to THA was the most common procedure. Therefore, understanding the pre-operative factors which may negatively affect the outcomes of HA is of primary importance. They can help surgeons to refin the indications for arthroscopic treatment of FAIS, to assist in shared decision making, and to set appropriate patient's expectations. Previous studies showed that chronic preoperative pain, chondral injuries and high BMI were predictive of clinical failure (6). Other factors are under investigation, as age, bone cyst, osteoarthritis and workers' compensation, but results are not univocal. This review aims to report the predictors of negative HA outcome, to guide the surgeon to identify the correct candidate to surgery, and to counsel patients on their expectations with regard to returning to pre-injury activities level after HA for FAIS.

MATERIALS AND METHODS

We performed a review of 3 databases (PubMed, Google Scholar, EMBASE). The searching process included the terms "femur acetabular impingement", "hip arthroscopy", "outcome", "failure", "revision rate", "total hip arthroplasty". The article research was extended from 2000 to 2020. The inclusion/exclusion criteria were determined a priori, and the abstracts were reviewed to determine the inclusion criteria. The inclusion criteria were English-language studies of all levels of evidence on humans. Particular attention was given to articles on FAIS arthroscopic treatment; the results produced were studied with visual analog scale, the modified Harris hip score, the hip range of motion (ROM), and clinical failure (revision hip arthroscopy rate and conversion to THA rate for any reason). Exclusion criteria were the lack of outcomes data, radiographic studies, studies that included adjunct procedure such as periacetabular osteotomy, tenotomy, human cadaveric studies, instructional course lectures, review articles. In addition, the meta-analysis with wide variability in patient-reported outcomes were not included due to impossibility of intra-study comparison data. The study has been performed according the international and ethical standards of the journal.

Three authors performed the literature research (ADM, MGM, RL) and they assessed the articles for study eligibility. Four reviewers (AGV, ADM, MGM, RL) independently extracted the relevant data from the included articles, and the patient-related factors associated with a less favorable outcome following hip arthroscopy were collected. Any discrepancies were resolved by discussion with FR, FO and GP, who supervised the study. AGV, ADM wrote the review.

RESULTS

The analysis of the database with the above mentioned key words produced 881 results. After duplicates have been removed and inclusion and exclusion criteria applied, 95 articles have been analyzed. Post-operative outcomes have been mainly evaluated with PROMs such as modified Harris Hip Scores (mHHS), Non-Arthritic Hip Score (NAHS), and Hip Outcome Score-Sport Specific Subscale (HOS-SSS)

The new studies showed that HA is an effective option for FAIS treatment. However, the results were variable and often contradictory. We hypothesized that same of the reasons at the base of this variability could be the heterogeneity of cohort, the small samples and the short follow-up. At the same time this review highlighted different pre-operative aspects that must be consider for a correct surgical indication as the base of a successful result.

Age

Age influences the result of FAI surgical treatment. Previous observational studies reported poor results in patients older than 40 years. A recent study, lead on almost 2000 patient, highlight that improvement of pain, PROMs and the quality of life are significantly better in young patients under 25 years-old than those one over 40 years-old after 2 years of follow-up. Unexpectedly, the worse clinical outcome has observed in patients between 25 and 40 years-old (9). This finding could be related to the higher expectation of younger patients. Similar results have been reported also by other authors (10, 11). However, a recent RCT compared hip arthroscopy versus nonoperative management for FAIS in patients older than 40 years and Tönnis grades 0-2 osteoarthrosis (12). The authors found a greater improvement of mHHS and iHOT in patients treated with HA compared to physical therapy alone, and concluded that age over 40 years should not be consider a contraindication to HA and labral repair.

A retrospective study on 106 patients, estimated the risk to THA conversion at 10 years follow-up, to be about 10% for patients younger than 40 years with a chondral injury form Grade 0 to II, according to Outerbridge classification
However, older age alone is not clearly considered a contraindication for HA. Different Authors reported good outcomes in patients older than 50 years (11). Mardones *et al.* (13) reported an improvement of functional score and pain in 87% of patients older than 60 years, at a mean follow-up of 4.4 years. At final follow-up 75% of the patients had a mHHS score of 70 or higher, and did not require any treatment. The conversion rate to THA was 13%, and the overall failure rate was 25%. Perets *et al.* (14) reported a statistically significan improvement of PROMs and patient's satisfaction in a sample of 94 patients older than 50 years, at minimum 5-year follow-up. The authors, by excluding from the study all patients with a Tönnis grade > 1, reported an overall survival rate of 72.3%. Patients who required secondary arthroscopy were 4.3% of the sample, and 27% THA. Patients who require early conversion to THA usually had a joint space smaller than 2 mm, higher body mass index, Tönnis grade greater than 1, smaller lateral center-edge angle, and higher percentage of Outerbridge grade 2 or higher on both the femoral and acetabular sides of the hip joint (15, 16).
In conclusion, age should not be considered a contraindication for HA per se. Although age and joint space narrowing are often correlated, significant improvement of pain and functional score have been reported in patients over 50 years old with no signs of advanced osteoarthritis. Different authors consider HA a reasonable option in well selected cases, but all patients should be counseled before surgery on the possibility of the conversion to THA.

Chondral injuries

FAIS is usually associated with chondral injuries, which can negatively affect the outcome of HA (**figure 1**). Although chondral damage is commonly observed during hip arthroscopy, the treatment is still controversial. Several strategies have been attempted to restore cartilage defects, in particular in active patients, but none of the treatments seems to be effective in case of large chondral defects, at middle and long-term. Chondral injuries and the need to perform acetabular microfractures have been reported to be predictive of the progression to HA revision and THA by many Authors, compared to patients without chondral damage (R.R 2.15 for HA revision rate; R.R. 2.86 for THA) (17-19).
Recently, Kester *et al.* (20) reported a revision rate and conversion to THA, at 4 years follow-up, respectively of 24% and 18%, in a cohort of 38 consecutive patients with Outerbridge grade 3 and 4 chondral lesions treated arthroscopically through microfractures. Although the postoperatory PROMs were significantly improved, the failure rate resulted higher compared to recent studies involving patients without chondral defects. Furthermore, the authors compared the same cohort of patients to a matched group with grade III-IV chondral lesion treated without microfractures reporting poorer results and higher conversion to THA rate for patients who received microfractures. Sogbein *et al.* (21) recently reported that evidence of chondromalacia and intra-articular damage are predictors of poor surgical outcomes.
An important limitation of literature is that different classific - tion systems are used to describe the chondral injury, making difficult to compare the outcomes of different studies (**table I**).
In conclusion, although patients could take advantage by hip arthroscopy, the worsening of clinical results is directly proportional to the gravity of chondral injuries.

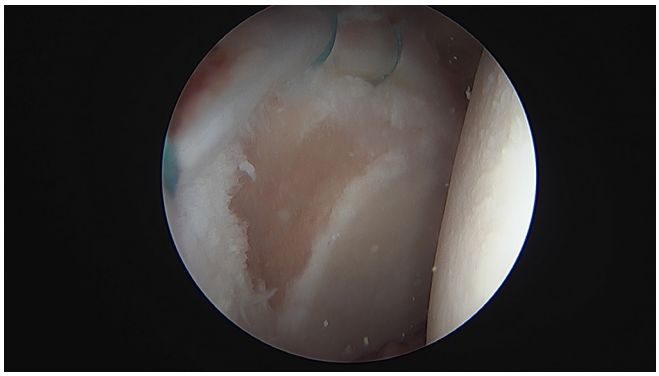

Figure 1. Acetabular chondral injury (Grade IV according to Beck's classification).

Table I. Classification of chondral injury of the hip.

Classification of International Cartilage Repair Society (ICRS)
Grade 0: no injury
Grade I: cartilage almost healthy
Grade II: macroscopic chondral alterations
Grade III: partial loosening of cartilage
Grade IV: complete exposition of subchondral bone
Beck's Classification
Grade 0: no injury
Grade I: fibrillar cartilag
Grade II: acetabular wave sign of carpet phenomenon associated with cartilage close to normal
Grade III: cartilage separation, bruised edge, reduction, fla
Grade IV: complete exposition of subchondral bone

Osteoarthrosis

The osteoarthrosis (OA) is recognized as a negative predictive factor, and it negatively affects improvements in pain and function after arthroscopy (22). OA and increased age are the most cited predictors for poor clinical outcomes and conversion to THA (23). Many authors consider contraindi-

cations for hip arthroscopy a joint space smaller than 2 mm, and a Tönnis grade equal or greater than 2 (**figure 2**) (24-26).

Figure 2. Tönnis Classification: **(A)** Grade 0 no arthrosis. **(B)** Grade 1: slight narrowing of the joint space, slight lipping at the joint margin, slight sclerosis of the femoral head or acetabulum. **(C)** Grade 2: presence of small bony cysts, further narrowing of the joint space, moderate loss of femoral head sphericity. **(D)** Grade 3: s large cysts, severe narrowing of the joint space, severe femoral head deformity, avascular necrosis.

Larson *et al.* (26) reported improvement of PROMs and lower failure rate compared to patients with an advanced joint space narrowing (33 *vs* 82% of failure rate). Patients with mild OA (Tönnis grade 1) are almost 3 times more likely to have inferior clinical outcomes compared to patients with a Tönnis 0. Nevertheless, Tönnis grade 1 is not a widely accepted contraindication to arthroscopic treatment of FAIS, regardless of the age (4, 27). Notwithstanding, within a young athletes population comparative analysis, successful outcomes have been reported in patients undergoing HA for FAIS with Tönnis grade 2, without statistically significant difference from the control group of patients with Tönnis grade 0 and 1 (28).
Worthy of mention are the moderate intraobserver and poor interobserver reliability of the Tönnis classification (29). The drawbacks and limitations of this classification should advocate a controversy about its usefulness in pre-operative screening.
In conclusion, hip OA with a Tönnis grade equal or higher than 2, or a residual joint space smaller than 2 mm can be considered a contraindication for HA.

Subchondral cysts - Bone marrow edema

Subchondral cysts are relatively common pathologies (**figure 3**), which can be observed in about 16% of patients at the MRI (30). These lesions have been associated with severe chondral injury (Outerbridge Grade III and IV), and are considered a sign of early OA, despite they can be observed also in asymptomatic patients. To date, there is not uniform consensus in literature, as some Authors consider the presence of subchondral cysts a contraindication for HA, while others did not find a significan correlation between cysts and early clinical failure. Recently, Hardigan *et al.* (31) reported a higher rate of THA conversion, in 65 patients undergoing HA, with preoperative MRI evidence of subchondral cysts. However, within the 80% survival rate at > 2-year, the authors reported a significant improvement in postoperative PROMs even in this population. Furthermore, no correlation between the presence of the cyst and intraoperative high grade chondral defect has been found. Probably the heterogeneity of these results is due to the different characteristics of these lesions, the location, and if there are symptomatic.

Figure 3. Isolated acetabular subcondral cyst.

When subchondral cysts are associated with bone marrow edema, the agreement among authors is stronger (**figure 4**). Krych *et al.* (32) showed that the association between chondral lesions, subchondral cyst and bone edema will worsen the clinical outcome when compared with patients

without subchondral cyst. According to the Authors, 91% of the patients with subchondral edema had an acetabular chondral injury of grade IV (Outerbridge) as patients presenting a single cyst > 5 mm.
In conclusion, with evidence of subchondral cysts and edema on preoperative MRI, HA should be approached with caution.

Figure 4. Acetabular chondral injury associated with bone edema.

Gender

There is no scientific consensus in literature about the infl - ence of gender on outcomes. Philippon *et al.* (33) reported that young female had worse clinical outcomes than males, with higher risk of revision hip arthroscopy. A large retrospective study, showed that although male patients usually have more serious acetabular cartilage lesions and larger labral tears at the time of surgery, the risk of requiring conversion to THA is 1.68-fold greater for female patients. In contrast, Mullins *et al.* (34) reported no differences between male and female patients in competitive athletes with respect to outcome scores.
Different Authors have tried to explain the discrepancy in clinical outcomes among gender. Sexual hormone may play a role in the arising of symptoms and postoperative compliances (33). Yeung *et al.* (35) demonstrated that hip instability was more common in female population after hip arthroscopy. Females tend to have smaller alpha angles, greater femoral and acetabular anteversion, and have lower center edge angles than males. Therefore, poorer results could be related to different anatomy of the pelvis, the increasing incidence of pincer, borderline hip dysplasia and micro-instability in female population. However, the biomechanics has not been definitivel established, and a significant difference in outcome scores has not been reported yet, although men are more inclined than women to coming back to sport (9).
The hypothesis that female gender is associated with poorer outcomes after hip arthroscopy compared to male, is still controversial. Currently, more females undergo hip arthroscopy in the United States than males, with significan - ly greater preoperative disability and lower PROMs than males (36). However, the same results are not reported in other long-term studies.

BMI

High body mass index (BMI) has been proposed to affect unfavorably clinical outcomes with increased risk of HA failure. Two Authors compared post-operatory outcomes between obese and normal weigh patients. Both of their studies showed short-term (2.5 years) clinical outcome improvements after HA but with lower overall PROMs scores. The clinical failure of primary HA was higher in the obese patients (O.R 4.7 and 2.2 for revision arthroscopy and conversion to THA respectively). When comparing other complications between the groups, no significan differences have been found.
A large study involving more than 3,900 patients have been performed to identify a definitive association between BMI and clinical outcomes. The Statewide Planning and Research Cooperative System (SPARCS) database study in New York, showed that obese patients have a risk to conversion to THA 5 times greater than patient with normal BMI (37). Unfortunately, there is a lack of evidence in literature regarding obesity and HA, and several confounding variables associated with higher BMI, as socioeconomic factors, sedentary lifestyle and comorbidities have been found. For example, diabetes, which is more common in obese population, have been reported to be an important risk factor for short and long term complications after HA, also affecting postoperative outcomes (38).

Duration of symptoms

The preoperative duration of symptoms (PDS) has been suggested to affect negatively clinical results. These include hip pain during active and passive mobilization of the hip, limitations of daily activities and decreased ROM Longer duration of preoperative symptoms may predispose patients to worse clinical outcomes and less significant improvement after HA (39).

Aprato *et al*. (40) reported significantly better outcomes for patients who underwent HA for FAIS within six months from symptom onset compared with those who waited longer. Patients who had symptoms for over 3 years by the time of surgery, had a significantly poorer result and higher HA revision rate. Therefore, the Authors recommend that patients with FAIS diagnosis should undergo hip arthroscopic surgery within six months of symptom onset. Another study, of Kunze *et al*. (39), included two homogenous cohorts of 310 patients: 190 with DPS < 2 years and 120 with DPS > 2 years. They demonstrated that the patients with PDS of 2 or more years had inferior outcomes and a lower significant improvement than the control group, at 5 years of follow up. However, they did not find a statistically significant correlation with revision HA (41). Furthermore, better outcomes may be achieved when patients undergo HA between 3 to 6 months from symptoms onset (40). A delayed treatment is considered a negative prognostic factor, because the repetitive edge loading may lead a labral intrasubstance degeneration and tears, chondrolabral delamination, and conversion to THA.

Preoperative PROMs

The severity of preoperative symptoms may influence the clinical outcome after HA. Preoperative PROMs have been proposed as a predictive factor of the final results. Different PROMs are available in literature for hip evaluation. The most appropriate and utilized PROMs for HA assessment are NAHS, iHOT-33, iHOT-12, HOOS, HOS, and HAGOS (42).

A prospective study of 1,038 patients by Domb *et al*. (43) demonstrated that preoperative NAHS positively correlated with postoperative measurement, meaning that the better the score before surgery, the better the score at final follow-up (2 years). A study including more than 900 patients found that lower preoperative iHOT-12 scores and longer duration of symptoms were predictive of poorer outcome at 2 years follow-up (4).

Patient's expectation and activity level may influence both preoperative and postoperative PROMs. Better outcomes expectations in athletic populations may be due to motivational differences and younger age between the groups (44). The WHOQOL-BREF (World Health Organization Quality of Life) have been proposed to assess the outcome of HA surgery (45). The WHOQOL is a quality-of-life assessment developed by the WHOQOL Group, which comprehensive appraise mental state and patients' perceptions of quality of life.

Workers' compensation may also negatively affect PROMs, both preoperative and postoperative. Nevertheless, patients with workers' compensation, even showing lower overall PROMs scores (20 points poorer), benefited from HA reaching the minimal clinically important difference (45, 46). While patient expectations may be adjusted on a case-by-case basis, Chala *et al*. (47) suggested that there are no significant correlations between high expectation scores and preoperative or postoperative PROs or patient satisfaction using mHHS, HOS-ADL and VAS scores.

Surgeon's experience

The experience of the surgeon can be considered a preoperative factor. A relevant outcome improvement is expected after 30 hip arthroscopies, even if it must be demonstrated how the surgical experience could affect the fina results (48).

DISCUSSION

Hip arthroscopy is a surgical procedure rutinary performed in many highly specialized hip surgical centers, and FAIS is the primary indication. The increasing interest is strictly connected to the concomitant improvement of FAIS knowledge and surgical techniques (49). HA is considered an effective and safe procedure and literature reports successful outcomes and high rate of return-to-sport. A progressive spreading of this surgical procedures as a widening of its indications have been recorded in the last fifteen years. The increased number of HA allowed to define also HA failure rate, defined as the need of revision hip arthroscopy or conversion to THA. Unfortunately, the relative paucity of long-term follow-up studies, the long-term outcomes are still not clear. Therefore, understanding the reasons which may be responsible of poor outcomes, may help surgeons to refine the indications for arthroscopic treatment of FAIS, to assist the patient-shared decision making, and to set appropriate expectations (**table II**). The rates of revision HA at 10 years follow-up ranged from 2% to 20.9%, and of conversion to THA from 2.5% to 32%, according to our reviewed studies (23, 50).

The age of the patient is a debated topic. Poorer results have been reported in patients older than 35 years, which is consider a predictor for an unsuccessful surgery by many Authors. However, older age is not considered a contraindication for HA by itself, although advanced age cannot be completely untied from underlying chondral damage and osteoarthrosis. Recent systematic reviews of literature concluded that OA is a recognized deleterious factor in HA, and that a Tönnis grade >1 increase significantl the clinical failure rate (21). However, HA can be considered a reasonable option in well selected over 50 years old patients, with preserved joint space and few sign of hip

Table II. Negative predictive factors for hip arthroscopy.

Statistically significant	Level of evidence	May affect	Level of evidence
Chondral injury both on acetabulum and femoral head (Grade III-IV ICRS)	Lev. IV (17-19)	Age	Lev. I (13) Lev. IV (9, 10, 12-15)
Osteoarthrosis (Tonnis scale ≥ 2)	Lev. I (11) Lev. III (25) Lev IV (15, 26, 28)	Female gender	Lev. I (36) Lev. IV (33, 34)
Articular joint space < 2 mm	Lev. I (11) Lev. IV (12, 13)	Duration of Symptoms	Lev. III (39-41)
Subchondral edema	Lev. III (32) Lev. IV (31)	Acetabular bone cysts	Lev. III (32) Lev. IV (31)
High BMI	Lev. III (37, 38)	Poor preoperative PROMs	Lev. I (36) Lev. III (40, 44, 47)
Working compensation	Lev. II (46) Lev. III (45)	Patient's expectations	Lev. III (47)
		Expercience of the Surgeon	Lev. II (48)

osteoarthritis (Tonnis grade I or lower), or for informed active patients who refuse a reconstructive surgery. Nonetheless each case should be strongly counseled before surgery on the further possible prospect of THA conversion. Femoral acetabular impingement is usually associated with chondral injuries or defects, which may negatively affect the outcome of HA. Many Authors agree that chondral damage is a predictor of poor surgical outcomes, and patients should be informed about the higher rate of clinical failure in these cases.

The presence of subchondral cysts is not an absolute contraindication for HA, but when bone edema is associated, clinical outcomes are significantly poore .

Poorer outcomes have been reported in female patients compared to male. This difference may be due to ligamentous hyperlaxity and a smaller alpha angle, a greater femoral and acetabular anteversion, and a lower center edge angles of female patients compared to males, which are suggestive of borderline dysplasia. Physician should be aware of atypical locations of cam lesions, borderline hip dysplasia, or ligamentous laxity, which could all contribute to poorer outcomes.

High BMI is a negative prognostic factor at short and middle-term follow-up, with higher rate of THA conversion (22).

The best HA timing for is still matter of debate. Recent studies showed that longer duration of symptoms may result in poorer patient outcomes at medium- and long-term follow-up. Better clinical outcomes have been reported when FAIS is treated arthroscopically within six months from the symptom onset. Furthermore, although both HA and personalized hip therapy improved hip-related quality of life for patients with FAIS, HA led to a greater improvement than conservative treatment (3). These results emphasize the importance of early and accurate diagnosis of intraarticular hip pathology, and that conservative treatment should be limited to a period of no more than 6 months from symptoms onset. Furthermore, lower preoperative PROMs have been related to poorer postoperative outcome. By this meaning, poorer preoperative conditions may be related to greater intra-articular damage, longer duration of symptoms, and age, which are both negative prognostic factors. For the same reason the real influence of low preoperative scores itself, is difficult to define. These findings should emphasize the importance of PROMs and the benefit in objectively recording the preoperative scores of our patients.

CONCLUSIONS

Hip arthroscopy is a safe and effective treatment for patients affected by FAIS, with a satisfaction rate close to 75%. However, these results are variable and sometime contradictory in literature. Unfortunately, there are mainly low-level evidence studies in small patient cohorts with short follow-up. Certain aspects such as chondral injury, osteoarthrosis, subchondral bone edema, high BMI are currently considered negative prognostic factors. Other factors as gender, isolated subchondral cysts, duration of symptoms and preoperative PROMs may negatively

affect the postoperative outcome scores. All these preoperative factors should be considered when arthroscopic treatment of FAIS is indicated. We hope that our study may help surgeons to improve their patient selection and expectations.

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None.

DATA AVAILABILITY

All the relevant outcome and results are included into the table of this manuscript. All the data are also available from the corresponding author under reasonable request.

CONTRIBUTIONS

FR, FO: study supervision and manuscript revision. AGV, ADM: literature revision and analysis, manuscript writing. MGM, RL: articles for study eligibility assessment and literature analysis.
GP: data collection, literature analysis and study supervision.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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