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Original article

A multimodal approach prevents instability after total hip arthroplasty: A 1 year follow-up prospective study

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ABSTRACT

Introduction: Joint dislocation is one of the most frequent complications after hip arthroplasty. Multiple strategies have demonstrated ability to prevent instability when used in isolation, but the effect when more than one intervention is implemented has not been measured. The purpose of this study is to assess the rate of dislocation after implementation of a protocol of combined strategies for prevention of instability.

Materials and methods: Consecutive patients undergoing primary total hip replacement for hip osteoarthritis between February 2012 and June 2014 were included. A multimodal protocol including patient education, use of large femoral heads, posterior soft-tissue repair, and intraoperative adjustment of limb length and hip offset was applied. Dislocation episodes were documented trough medical records review and a telephonic follow-up at 3 and 12 months after surgery.

Results: During the period of study 331 patients were included, mean age was 66 years and 68.8% were females. Only 0.91% of patients were lost to follow-up. Eighty-nine percent of patients received all interventions. Cumulative dislocation rate at 3 months was 0.60% and 0.90% at 12 months.

Conclusions: The implementation of a multimodal protocol for prevention of prosthesis instability produces a low rate of dislocation, which compares favorably with benchmarks. We recommend the use of a combination of multiple interventions to prevent this complication.

1. Introduction

Prosthesis dislocation is one of the most frequent complications after hip arthroplasty.[1] The prevalence of this complication ranges between 0.2 and 7%[1–3] and it is the third cause of revision surgery after aseptic loosening and periprosthetic infection.[4–7] Despite that two thirds of the cases of instability can be resolved with non-surgical treatment,[8] the Australian National Registry of Joint Replacements reports that 13–42% of re-operations are due to this complication.[9] Although dislocation might occur at any moment after implantation of the hip prosthesis, it has been described that there is a high risk for dislocation during first 3 months after surgery.[1,10,11] Meek et al. reviewed the Scottish National arthroplasty non-voluntary registry and found that 23% of dislocations occurred during the first 3 months and 43% between 3 and 12 months.[12]

Instability after primary total hip replacement is associated with multiple risk factors that depend on the characteristics of the patient, surgical technique and implant selection.[1,8,9,13,14] Factors related to patients are: gender, age, obesity, ASA (American Society of Anesthesiologists) classification, epilepsy, neuromuscular disorders, ligamentous laxity, rheumatoid arthritis, avascular necrosis of the femoral head, intracapsular fractures.[9,15,16]

On the other hand, factors associated with the procedure such as surgical technique, implant selection, restoration of limb length and offset, adequate implant positioning, use of large femoral heads,[17,18] and posterior soft-tissue repair (posterior capsule, piriformis tendon, and conjoined tendon),[13,19] have demonstrated

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to prevent instability when used in isolation,[20,21] but the effect, when more than one intervention is implemented, has not been measured. Therefore, a multimodal protocol for prevention of instability has been developed and implemented in our institution in order to diminish the risk of dislocation after total primary hip arthroplasty.

The contribution of this study to current orthopedic knowledge is to report the rate of dislocation when a multimodal protocol for prevention of instability is implemented. It further seeks to describe the rate of dislocation after total primary hip arthroplasty when multiple proven strategies are combined for prevention of instability, which is yet to be reported in current orthopedic studies.

2. Materials and methods

A prospective cohort study was conducted, including consecutive patients who were scheduled for primary total hip arthroplasty and in whom the multimodal protocol for prevention of instability was implemented, between February 2012 and June 2014. Identification of cases of dislocation was carried out by telephonic follow-up at 3 and 12 months after the date of surgery. Every patient included for analysis had a 12 month follow-up assessment. Patients requiring hip arthroplasty for hip fractures or oncologic pathology and cases in which a constrained or dual mobility acetabular component was used were excluded. This decision was made considering that one or more of the interventions could not be implemented in these groups of patients as well as the fact that dual mobility components produce a lesser risk of dislocation than conventional implants.[22–24]

2.1. Surgical technique

Patients were positioned in lateral decubitus ensuring that the pelvis was parallel to the horizontal plane. In all patients, a posterolateral mini-incision approach was used.

2.2. Multimodal protocol for prevention of instability

1. Patient education: patients were educated on safe behaviors following hip replacement surgery. Additionally, a booklet was provided and patients were invited to a group talk where the goals of the procedure, the surgical technique, rehabilitation plan and measures to prevent dislocations were explained and discussed. These topics were also reviewed individually during hospitalization.
2. Intraoperative adjustment of limb length, femoral offset and articular-trochanteric distance: reference measures of these parameters are obtained from the native hip. After final components were placed, a last measurement was performed to determine whether the goals of restoration of limb length, femoral offset and articular-trochanteric distance were achieved. These measurements were performed with the aid of a leg length and lateral offset measurement device (Llinas Leg Length and Lateral Offset Gauge – Innomed, Inc. Savannah, Georgia). This gauge allows surgeons to calculate the distance from a fixed point in the ilium to the lateral cortex of the greater trochanter, thus providing accurate data on leg length and lateral offset.
3. Accurate orientation of prosthetic components: adequate acetabular cup positioning was attempted with the use anatomic landmarks and an inclinometer. The goal was to obtain 15–25° of anteversion and 40–50° of inclination.
4. Use of large femoral heads: according to intraoperative findings, femoral heads $\geq$32 mm whenever it was possible.
5. Intraoperative assessment of prosthetic hip stability: with trial components in place, stability was assessed at the following positions: (a) 120° of flexion, (b) combination of 45° of flexion, 15° of adduction, neutral rotation and 45° of internal rotation, and (c) full extension and maximum external rotation. Whenever the test was not satisfactory, adjustments of trial components were made in order to achieve stability once definitive components were implanted.
6. Posterior soft-tissue repair: with the hip joint in neutral position, posterior capsule and short external rotators were repaired independently with one sutures and re-attached to the greater trochanter through two drill holes.

2.3. Statistical analysis

Descriptive analysis on demographic data, frequency of implementation of each intervention and the rate of dislocation during 3 months after the surgery was performed.

3. Theory

As previously stated prosthesis instability remains one of the most common causes of revision surgery after total hip replacement. There exists several strategies for the prevention of this complication however, to the best of our knowledge, there are no descriptions in the literature regarding the effect of combining these strategies. Therefore this study seeks to describe the implementation of a protocol for prevention of hip prosthesis dislocation that includes 6 different approaches, and to its impact on the rate of dislocation. In theory this protocol may be more effective for the prevention of instability and lay the path for further studies on this multimodal strategy.

4. Results

During the period of study 331 patients were included, 228 females and 103 males. Mean age was 66.2 years. Three patients (0.91%) were lost to follow-up: 2 patients died within the first month after surgery and 1 patient was not available for contact (Table 1). With the exception of these losses to follow-up, patients were contacted at 3 months and 1 year after surgery.

Eighty-nine percent of patients (295/331) received all interventions. All patients received education according to parameters established (Table 2). Posterolateral approach was performed in all patients and posterior soft-tissue repair was completed in 98.5% of them. The caliper was used to restore limb length and femoral offset in 90.63% of cases and the inclinometer was used for cup orientation in 300 patients. Similarly, 97.58% of patients received physical therapy at home (Table 2).

Table 1
Summary of demographic characteristics of patients included in the study.

Variable	*N*	Percentage
Total of procedures	331	100%
Mean age	66.14	
Gender		
Females	228	68.88%
Males	103	31.12%
Diagnosis		
Primary osteoarthritis	247	74.6%
Secondary osteoarthritis		
Developmental hip dysplasia	26	7.9%
Rheumatoid arthritis	16	4.8%
Post-traumatic	16	4.8%
Avascular necrosis	12	3.6%
Other	14	4.2%
Lost to follow-up	3	0.91%
Death	2	0.60%
Unable to contact	1	0.30%

Table 2
Percentage of implementation of interventions from the multimodal protocol.

Intervention	*N*	Percentage
Education	331	100%
Booklet	307	92.75%
Group talk	52	15.71%
Other	32	9.70%
Surgical approach		
Postero-lateral	331	100%
Largest femoral head size mm		
< 32 mm	64	19.34%
≥ 32 mm	265	80%
No data	2	0.60%
Use of intraoperative caliper	300	90.63%
Intraoperative assessment of instability	328	99.09%
Soft-tissue repair		
Yes	326	98.49%
No	4	1.21%
No data	1	0.30%
All interventions	295	89.12%

At the three-month follow-up, 2 cases (0.60%) of prosthetic dislocation were identified. First case presented with dislocation 12 weeks after surgery and was successfully treated with close reduction under general anesthesia. The second case dislocated after 8 weeks and following close reduction, presented three more episodes of dislocation, requiring revision surgery 4 months after primary procedure. During this surgery a detachment of posterior elements and retroversion of the femoral component were found. Adequate positioning of the acetabular cup and no signs of infection were observed. The femoral component was exchanged in order to obtain prosthetic stability.

At the 1-year follow-up three cases (0.91%) were identified. Two of these cases were re-dislocations of the cases described above. The latter also presented with prosthetic joint infection that required two-stage revision surgery. The remaining case was an isolated episode of dislocation.

5. Discussion

Hip replacement surgery is a safe and effective procedure for the treatment of osteoarthritis and hip fractures. Regardless the high level of standardization of this procedure, instability remains one of the most frequent and disturbing complications.[1–3] Although several strategies have demonstrated to be effective in reducing dislocation rates, to the best of our knowledge this is the first time that a multimodal protocol comprising these interventions has been assessed in a prospective manner.

Factors that increase the onset of this complication can be classified as non-modifiable, which are related to the patient,[9,15,16,25] and modifiable, those that can be controlled and fully depend on the surgical technique and perioperative management.[8,9,13,15,16,25–27]

Posterolateral approach has been typically associated with an increased risk of posterior dislocation,[11,13] however, there is no agreement in the literature concerning the effect of this approach on prosthetic instability and some studies suggest that the approach should be based on patient factors, the surgeons preference and experience.[27] Li et al. reported that in 95% of cases of dislocation, a posterior approach had been used, having a significant effect on prosthesis survival.[11] On the other hand, Ji et al. found a reduction in the risk of dislocation with the use of posterior approach compared to the lateral approach.[13] In this study, all patients were operated through a posterolateral approach, which provides an optimal scenario to measure the effect of strategies for prevention of instability.

It has been described that the rate of dislocation decreases with the use of prosthetic femoral heads larger than 28 mm.[17,20,28,29] Hailer et al. also analyzed a group of patients from the Swedish Hip Arthroplasty Registry and found that patients in whom 32 and 36 mm femoral heads were used, had a relative risk (RR) for revision of 0.8 compared to patients with 28 mm femoral heads.[18] Similarly, Jameson et al. reported a reduction of cumulative dislocation rates from 1.12% to 0.86%, after increasing femoral head size.[30]

Since implant positioning is also a determining factor for stability, the acetabular component must be implanted with an orientation of $45 \pm 10^{\circ}$ of inclination and $15 \pm 10^{\circ}$ of anteversion.[20] This positioning angles are defined in the literature as the "safe zone" and it has been widely demonstrated that prosthesis outside this range have higher risk of posterior dislocation.[20,31,32] McCollum et al., described that the highest range of stability was found with acetabular cup position between 30 and 50° of abduction, and 20–40° of anteversion, however, this study reports a rate of dislocation of 1.14%.[2]

Restoration of limb length and articular offset (defined as the distance between the center of rotation of the femoral head and the longitudinal axis of the femur) also have demonstrated an impact on prosthesis stability and survival.[33,34] Restoration of hip anatomy and biomechanics in order to decrease the rate of dislocation[35] can be achieved with the use of intraoperative devices like calipers.[36] Robinson et al. describes a rate of dislocation of 1.3% (9/668) and found that in 8 of the 9 cases (1.19%) the primary cause of dislocation was failure to restore these anatomic parameters.[37] Similarly, systematic repair of short external rotators and posterior capsule reduces the occurrence of instability to a rate of 0.85%.[13,19]

All strategies mentioned above have demonstrated ability to prevent instability when used in isolation but, to the best of our knowledge, the effect when more than one intervention is implemented has not been measured yet. Accordingly, we combined these different strategies in a multimodal protocol: patient education, use of large femoral heads, posterior soft-tissue repair, intraoperative adjustment of stability, limb length, offset and articular-trochanteric distance.

With the systematic implementation of this protocol we found a rate of dislocation of 0.60% during a three-months follow-up period, which is the moment when most of instability episodes have occurred.[1,10–12] This rate varies considerably in comparison to our previous reports where dislocation was present in 5.8% of patients with similar demographic characteristics. A reduction in the rate of postoperative instability denotes that the implementation of multiple strategies is effective for the prevention of this complication and could have a significant impact in the long-term survival of implants.[4,9,29] Additionally, it indicates a highly standardized surgical procedure characterized by low variability among surgeons.

In the patient who presented with 4 episodes of dislocation, no individual-related factors that could increase the risk of dislocation were identified[15,16] and femoral component retroversion and the rupture of posterior soft-tissue remained to be the main causes of instability.[15,19]

The strengths of this study were: sample size, including 331 consecutive patients from our cohort of hip arthroplasty, the follow-up time, that allowed us to detect most cases of dislocation,[1,10–12] the low frequency of patients lost to follow-up and that all interventions were implemented in almost 90% of all patients. Conversely, one of the limitations of this study is that due to its design and the low frequency of study outcome, we were unable to assess the individual effect of each intervention. In addition, the small proportion of patients at higher risk of prosthesis dislocation (rheumatoid arthritis, developmental hip dysplasia, posttraumatic arthritis, etc.) (Table 1), restricts the external validity of the results in these populations. Another

limitation is that while arthroplasty after hip fracture surgery is associated with a higher rate of dislocation,[9,15] these patients were excluded from the analysis due to the great variability on the surgical technique, types of implants used and the limitation to determine whether the multimodal protocol was implemented in these patients.

6. Conclusion

With the implementation of multiple preventive strategies for dislocation, we obtained results comparable to the lowest dislocation rates previously reported in the literature.[1,2] Thus, we consider that the implementation of combined strategies during hip replacement surgery is more effective than their use in isolation and we recommend the implementation of a multimodal protocol for prevention of prosthetic instability.

Research involving human participants and/or animals

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

Ethical approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Informed consent

Local IRB did not request the consent form patients as per the study design.

Conflicts of interest

- *Dr. Omar Amado* has nothing to disclose.
- *Dr. Maria Bautista* has received other financial support from DePuy Synthes (Orthopedics) and Grunenthal, outside this work.
- *Dr. Jose Moore* has nothing to disclose.
- *Dr. Guillermo Bonilla* has participated as paid speaker for Boehringer-Ingelheim, Pfizer, Bristol-Myers-Squibb, DePuy Synthes (Orthopedics) and Stryker; has received other financial support from DePuy Synthes (Orthopedics) and Grunenthal, outside this work.
- *Nicolas Jimenez* has nothing to disclose.
- *Dr. Adolfo Llinás* has received royalties from Innomed; has participated as paid speaker for Zimmer, Bayer, Covidien, Ethicon, Pfizer, Novonordisk, Baxter, 3 M, Biotest and Procaps; has participated as paid consultant for Ethicon, Zimmer and Bayer, outside this work.

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