E F O R T *open reviews*

Human immunodeficiency virus in total hip arthroplasty

Jurek Rafal Tomasz Pietrzak
Zia Maharaj
Lipalo Mokete
Nkhodiseni Sikhauli

■ Human immunodeficiency virus (HIV) is a pandemic affecting more than 35 million people worldwide. The aim of this review is to describe the association between HIV and total hip arthroplasty (THA) and assess patient risk factors to optimize functional outcomes and decrease rates of revision.

■ Since the advent of highly active antiretroviral treatment (HAART), HIV-infected patients are living longer, which allows them to develop degenerative joint conditions. HIV and HAART act independently to increase the demand for THA. HIV-positive patients are also more predisposed to developing avascular necrosis (AVN) of the hip and femoral neck fractures due to decreased bone mineral density (BMD).

■ Prior to the widespread implementation of access to HAART in homogenous cohorts of HIV-infected patients undergoing THA, reports indicated increased rates of complications. However, current literature describes equivocal functional outcomes and survival rates after THA in HIV-positive patients controlled on HAART when compared to HIV-negative controls.

■ HIV-infected patients eligible for THA should be assessed for medical co-morbidities and serum markers of disease control should be optimized.

■ Periprosthetic joint infection (PJI) is a leading cause of revision THA, and HIV is a modifiable risk factor. Importantly, the significance is negated once patients are placed on HAART and achieve viral suppression.

■ THA should not be withheld in HIV-infected patients injudiciously. However, HIV is a burgeoning epidemic and all patients should be identified and started on HAART to avoid preventable peri-operative complications.

Keywords: human immunodeficiency virus; immunocompromise; total hip arthroplasty

Introduction

The prevalence of human immunodeficiency virus (HIV) patients undergoing total hip arthroplasty (THA) is increasing worldwide. HIV is a pandemic affecting over 35 million adults (prevalence 0.8%).[1] The European Centre for Disease Prevention and Control reports that HIV transmission remains a 'major public health concern' with over two million people living with HIV in the European Region and 159,420 new diagnoses made in 2017 (see Table 1).[2] There are an estimated 120,000 people living with HIV in the United Kingdom (UK).[2] The rate of new diagnoses in the UK is 11.4 per 100,000 people, which is almost double the rate of most other countries in western Europe.[3] Whilst in eastern Europe there is a burgeoning epidemic with 998,525 people living with HIV in Russia and 244,000 in Ukraine, alone.[2] Furthermore, over half (53.1%) of those newly diagnosed in the European Region have a CD4+ T-cell count (CD4+) < 350 cells/mm³. HIV-infected patients are at a greater lifetime risk of requiring THA. The aetiology is multifactorial, with causative mechanisms related to both the disease itself and treatment with highly active

Table 1. Global HIV statistics

Region	People living with HIV	New infections in past year
Middle East and North Africa	220,000	18,000
Asia and Pacific	5,200,000	280,000
Europe	2,000,000	159,420
• United Kingdom	120,000	6,095
Eastern Europe and Central Asia	1,400,000	130,000
• Russia	998,525	105,844
United States (US)*	1,140,400	50,000
Latin America	1,800,000	100,000
West and Central Africa	6,100,000	370,000
Eastern and Southern Africa	19,600,000	800,000
• South Africa	7,200,000	270,000
• Nigeria	3,100,000	210,000
• Kenya	1,500,000	53,000

*Latest statistics available from 2017, except US (2016).
Source. UNAIDS,[1] ECDC,[2] CDC.[35]

antiretroviral treatment (HAART).[2] It is controversial whether HIV-positive patients are at higher risk for adverse THA outcomes; however, poor immune status has been linked to increased incidence of complications. A fundamental understanding and approach to the interaction of HIV and THA is critical.

The pandemic nature of HIV underlines the importance of global expenditure. Worldwide, US$21.3 billion was spent on HIV in 2017 and it is estimated that US$26.2 billion will be required for the acquired immunodeficiency syndrome (AIDS) response in 2020.[1] Concurrently, the demand for THA is already high and continues to rise. Approximately 91,698 procedures were performed in England and Wales in 2017.[4] There are over 300,000 cases being performed in the United States of America (USA) annually, and this is projected to increase by 173% to 572,000 procedures by 2030.[5] Compounding this strain, hospital re-admissions up to 90 days after THA represent a massive economic burden on healthcare systems.[6] The total annual cost for 90-day readmissions after THA is approximately US$477 million in the USA, alone.[6] Approximately half of these re-admissions are due to medical co-morbidities and are unrelated to the joint replacement procedure itself.[6]

Despite the development of several preventative measures, the annual incidence of peri-prosthetic joint infection (PJI) in THA is 1.17% and has a five-year mortality rate of 21.12%.[7] The annual cost for revisions due to PJI was US$566 million in 2009 and is expected to increase to US$1.62 billion by 2020.[8] There were 8,073 revisions and 3,045 re-revisions in England and Wales in 2017.[6] PJI is the third most common indication for revision hip arthroplasties[8] and may be a result of both modifiable and non-modifiable risk factors. Non-modifiable risk factors associated with an increased risk of infection[9] include age, gender, race and chronic diseases such as obstructive pulmonary or kidney disease, coagulopathies and cirrhosis.[10] Modifiable risk factors have been shown to prolong the length of hospital stay and add to both the complication and early revision rates. These factors include obesity, poor dentition, opioid use, smoking, diabetes, *Staphylococcus aureus* colonization and HIV.[10]

A clustering of co-morbid risk factors may also exist in HIV-infected patients undergoing THA. Additionally, the 2018 International Consensus on Orthopedic Infections determined that HIV posed an independent risk for PJI.[11] However, the significance was negated once HIV-infected patients were placed on HAART and optimized pre-operatively.[11] It is therefore imperative to identify and optimize HIV-positive patients prior to surgery in order to decrease the strain on already heavily burdened healthcare systems globally. A fundamental understanding and approach to the interaction of HIV and THA is critical. Additionally, this narrative review serves to highlight crucial aspects of the peri-operative management of HIV-infected patients undergoing THA necessary to optimize outcomes and reduce complications.

Association between HIV and THA

The burden of THA will be compounded worldwide as the HIV pandemic spreads. Whilst HIV incidence steadily increases, global access to HAART for those infected has improved from 25% to 59% between 2010 and 2017.[1] As a result of improved access to HAART, a decline of 52.7% in AIDS-related mortality globally has been seen in 2017 since its peak in 2004.[1] People are living longer due to improved access to HAART and are subsequently developing chronic degenerative joint diseases. Both the HIV disease itself and HAART used to treat HIV have independently been linked to hip pathology eventually necessitating joint replacement.[12] HIV-positive patients are more predisposed to developing avascular necrosis (AVN)[13] of the hip and femoral neck fractures due to decreased bone mineral density (BMD).[14] Furthermore, the incidence of AVN has increased since the advent of HAART.[13]

HIV and HAART have been implicated by several epidemiological studies as causes of AVN. Femoral heads are most frequently involved in HIV- and HAART-related AVN.[13] Reports have indicated that the incidence of femoral head AVN in HIV-infected patients may be 45- to 100-fold greater compared to the general population.[13,15] HIV-infected patients with osteonecrosis require THA at a younger age than patients affected by osteoarthritis, and joint involvement is often bilateral (Fig. 1).[16]

Fig. 1 Anteroposterior (AP) view of a 37-year-old HIV-infected male patient with a CD4+ of 438 cells/mm^3 and an undetectable VL on HAART with bilateral femoral head AVN.

Note. CD4+, CD4+ T-cell count; VL, viral load; HAART, highly active antiretroviral treatment; AVN, avascular necrosis.

Fig. 2 Anteroposterior (AP) view of a 69-year-old HIV-infected female patient with a CD4+ of 327 cells/mm³ and an undetectable VL on HAART with femoral neck fracture after a fall from standing height. The patient had chronic left hip pain for two years before this incident and the radiograph shows evidence of osteodegeneration with loss of joint space, osteophytosis and cysts in the femoral head. The right hip is pain free.

Note. CD4+, CD4+ T-cell count; VL, viral load; HAART, highly active antiretroviral treatment.

HIV negatively impacts BMD and HIV-infected patients are 3.7 times more likely to be osteoporotic than non-infected patients.[14] Subsequently, an increased risk of fragility fractures in HIV-infected patients exists, especially femoral neck fractures in males (Fig. 2).[16] Risk factors associated with low BMD include low CD4+ nadir and longer duration of HIV infection.[14] With no sign of disease retrenchment and widespread improvements in access to HAART, patients for THA should be routinely screened for HIV.[13]

Evaluation and optimization of immune status

Optimization of the patient's immune status is essential in the management of HIV-infected patients undergoing THA. Immunocompromised patients and those with uncontrolled virological status need to be identified in order to minimize peri-operative complications.[17] Serum markers of disease control are CD4+ and viral load (VL).[18] These markers should be measured pre-operatively if no result is available within the previous three months.[17] CD4+ is a surrogate marker of immune status and a CD4+ < 200 cells/mm³ confirms the diagnosis of AIDS.[19] In patients with CD4+ < 200 cells/mm³ there is increased incidence, morbidity and mortality due to opportunistic infections.[17] Antibiotic prophylaxis should be initiated for

all patients with CD4+ < 200 cells/mm³.[19] Latest guidelines recommend trimethoprim-sulfamethoxazole (TMP-SMX) as prophylaxis for opportunistic infections.[19]

Viral load is a reliable marker of treatment efficacy and is primarily dependent on patient adherence to medication.[19] Patients adherent to HAART should have an undetectable VL, which is approximately < 50–100 copies/mL. If after 6–8 weeks with strict treatment adherence, the VL is > 1000 copies/mL or there has been a decrease in VL of less than one *log* from baseline measurement, there is virological failure.[19] Patients with virological failure should be referred to an infectious disease specialist for assessment and elective surgery should be postponed.

HAART: changing HIV from a terminal to a chronic illness

Latest guidelines recommend that HAART should be initiated in every patient with confirmed HIV infection, regardless of clinical stage and with any CD4+.[19] This is especially important in patients awaiting elective THA. All first-line HAART regimens consists of a dual nucleoside reverse transcriptase inhibitor (NRTI) combination plus a third agent from a different drug class. Some of the most recent global and regional guidelines are shown in Table 2. Protease inhibitors (PIs) are regarded as the main drug class contributing to AVN of the hip.[12] Additionally, tenofovir-containing drugs are implicated in the development of osteopenia.[17] Interestingly, all first-line regimens worldwide include a tenofovir-containing agent (see Table 2). This may subsequently further add to the global burden of THA with femoral neck fractures and even revision THA as a consequence of peri-prosthetic fractures.

There is ongoing research into the development of more ideal pharmaceutical agents due to the multiple adverse effects caused by current HAART regimens. The renal and osteodegenerative adverse effects of tenofovir disoproxil fumarate (TDF) have resulted in the development of tenofovir alfenamide (TAF).[20] TAF still causes renal injury and bone loss, although damage is less extensive

Table 2. Latest adult HAART first-line regimen guidelines

World Health Organization (WHO), 2016	2 NRTIs + NNRTI	TDF + 3TC/FTC + EFV
	2 NRTIs + InSTI	TAF + 3TC/FTC + DTG
International Antiviral Society (IAS) – USA	2 NRTIs + InSTI	TAF + FTC + DTG
British HIV Association (BHIVA)	2 NRTIs +InSTI	TAF + FTC + DTG
Southern African HIV Clinicians Society (SAHCS)	2 NRTIs + NNRTI	TDF + 3TC + EFV

Note. NRTIs, nucleoside reverse-transcriptase inhibitors; NNRTI, non-nucleoside reverse-transcriptase inhibitor; InSTI, integrase strand transfer inhibitor; 3TC, lamivudine; AZT, zidovudine; d4T, stavudine; DTG, dolutegravir; EFV, efavirenz; FTC, emtricitabine; NVP, nevirapine; TDF, tenofovir; TAF, tenofovir alafenamide. *Sources.* WHO,[36] IAS,[37] BHIVA,[38] SAHCS.[19]

than with TDF.[20] The common metabolic side effects and high cost of PIs have led to the advent of integrase strand transfer inhibitors (InSTIs) as the preferred first-line regimen recommendation by the WHO.[20] Standard practice in the USA and UK already includes InSTIs. Whilst over half the global prevalence of HIV (53%) is in eastern and southern Africa, these areas do not yet have access to InSTIs in public healthcare.[20]

Pre-operative optimization

HIV can impact multiple systems and patients must be fully assessed for peri-operative risk stratification before THA. Non-AIDS-associated diseases commonly found in HIV-infected patients include cardiovascular disease, renal disease, liver disease, neurological complications and malignant conditions.[21] Pre-operative evaluation of HIV-positive patients must include appropriate blood work-up including serum albumin, nutritional state and stage of immune deficiency syndrome.[22] Studies indicate that postoperative complications in HIV-positive patients are primarily caused by resultant immunodeficiency rather than the operation itself.[17] Therefore a thorough evaluation is imperative to avoid both anaesthetic and surgical complications and improve functional outcomes after THA.

Nutritional state

Nutritional state should be assessed in all HIV-positive patients with advanced disease as they are at risk for wasting and nutritional deficiencies.[17] Hypoalbuminaemia is an independent risk factor for post-operative mortality in HIV-positive patients when compared to uninfected controls.[23] Malnutrition is associated with several complications after THA, including delayed wound healing, persistent wound drainage with subsequent susceptibility to infection and prolonged hospital stay.[11] Nutritional supplementation may be warranted if oral intake is inadequate and a dietician should be consulted.[17]

Cardiovascular risk

Cardiovascular disease has become a significant cause of death in HIV-positive patients.[17] Retrospective studies indicate an increased risk of coronary artery disease amongst HIV-positive patients when compared to HIV-negative controls, which may be related to ongoing chronic inflammation, despite viral suppression.[17] Initiation of HAART has been shown to reduce cardiovascular risk peri-operatively.[21] Concomitantly there are metabolic adverse effects of specific agents to consider.[17] There is an increased prevalence of insulin resistance, diabetes mellitus and hypercholesterolaemia in HIV-infected patients on HAART.[17] This may contribute to the increased risk of femoral head AVN and

subsequently the increased demand for THA in HIV-positive patients. Thorough clinical examination for lipodystrophic changes and a fasting lipogram should be carried out on all HIV-positive patients for THA, especially if they are on a HAART regimen including a PI.

Pulmonary function

The prevalence of smoking is over 40% higher in HIV-positive patients and the likelihood of cessation is less than in the general population.[24] This predisposes these patients to atherosclerotic processes as well as chronic pulmonary disease and post-operative pulmonary infections.[17] Pulmonary function tests should be performed on all HIV-positive smokers to assess diffusion capacity prior to elective surgery.[17] Furthermore, AIDS patients are at risk for invasive bacterial nosocomial pathogens and elective THA should be postponed to allow for effective immune reconstitution.[17]

Adverse effects of HAART

There are many adverse effects of HAART agents and the regimen that the patient is taking must be noted. PIs and non-nucleoside reverse-transcriptase inhibitors (NNRTIs) have significant drug interactions with anaesthetic agents used for induction and sedation.[17] TDF is nephrotoxic, and these patients will require a blood urea nitrogen (BUN) test to assess renal function, with or without a urine protein-creatine ratio.[19] Zidovudine (AZT) causes anaemia and neutropenia, and these patients will require a complete blood count (CBC) and white cell count (WCC) including differential count.[18]

THA outcomes in HIV-infected patients

There are conflicting findings in the literature regarding functional outcomes in HIV-infected patients undergoing THA. Much controversy still exists regarding the relative safety and efficacy of THA in HIV-infected patients. Common knowledge previously suggested an increased risk of adverse outcomes, especially infective complications, as a consequence of HIV infection. However, the literary landscape may have been tainted by studies evaluating homogenous groups of HIV-positive patients including haemophiliacs and intra-venous drug users (IVDUs). Furthermore, the widespread implementation of access to HAART has decreased the morbidity of the disease. Unfortunately, many studies do not specify whether patients were receiving HAART or record the serum measurements of disease control to assess immune status. The details of several studies are outlined in Table 3. In order to analyse the available data we will assess the current literature according to study cohorts including haemophiliacs

Table 3. Summary of selected papers demonstrated outcomes of THA in HIV-infected patients

Study	Number of participants		HIV+ disease control assessment		Results		Comments
	HIV+	HIV- control	Receiving HAART (%)	Mean CD4+ (cells/mm³)	Post-operative infection* rate (%)	Revision rate (%)	
Ragni et al (1995)[25]	66		N/A	N/A	15.1	N/A	Included HEM with CD4+ < 200
Lehman et al (2001)[26]	29		0	N/A	14,3 DJI	N/A	Included IVDUs
Enayatollahi et al (2016)[27] *Systematic review*	293 non-HEM 341 HEM		*N/AE*	*N/AE*	non-HEM vs. HEM (2.28 vs. 10.98) [OR 0.12]	*N/AE*	HAART associated with fewer infections overall
Parvizi et al (2003)[28]	15		20	523	29 DJI	62	Mean CD4+ patients with DJI was 239
Lubega et al (2009)[39]	18	40	100	543	0	5.6	• 17/18 (94%) HIV+ were newly diagnosed • All patients initiated on HAART prior to THA
Tornero et al (2012)[40]	13	27	100	434	0	0	
Issa et al (2013)[32]	34	70	N/A	N/A	HIV+ vs. HIV- (5.8 vs. 0.0)	N/A	
Capogna et al (2013)[41]	69	138	N/A	N/A	HIV+ vs. HIV- DJI (4.40 vs. 0.72)	N/A	NO HIV+ with DJI had UVLs, but all had CD4+ > 350
Graham et al (2014)[29]	29		100	489	0	0	
Falakassa et al (2014)[42]	24		100	647	0	4.2	• VL : UVL 79%, N/A 21% • HIV+ on HAART with UVL and CD4+ > 200 have equivalent infection risk to general population
Snir et al (2014)[43]	31		100	444	2.4 DJI	7.3	UVL 77%
Lin et al (2014)[44]	22	372	95	N/A	HIV+ vs. HIV- DJI (9.1 vs. 2.2)	N/A	• No infection in patients with CD4+ < 200 • Low CD4+ not an absolute contraindication to TJA
Naziri et al (2015)[30] *Systematic review*	9275	2 656 696	*N/AE*	*N/AE*	HIV+ vs. HIV- wound infection (0.7 vs. 0.2) [OR 2.38]	*N/AE*	May include HEM and IVDUs
Dimitriou et al (2017)[16] *Systematic review*	11 431	6 504 755	*N/AE*	*N/AE*	HIV+ vs. HIV- (7.6 vs 3.3)	*N/AE*	HEM excluded, may include IVDUs

Note. HIV+, HIV-positive patients; HIV-, HIV-negative patients; HAART, highly active antiretroviral treatment; CD4+, CD4+ T-cell count (in cells/mm³); HEM, haemophiliac; IVDU, intra-venous drug user; DJI, deep joint infection; OR, odds ratio; VL, viral load; UVL, undetectable viral load (< 50 copies/mL); THA, total hip arthroplasty; TJA, total joint arthroplasty.
N/A, not available – data not recorded or mentioned; N/AE, not available or evaluated routinely in all papers analysed.
*Post-operative infection refers to peri-prosthetic joint infection, unless otherwise specified as DJI or wound infection.

and/or IVDUs and studies conducted before and after the peak in AIDs mortality due to poor HAART access.

Haemophilia and HIV

Historically, outcomes of THA in HIV-infected patients have included both haemophiliacs[25] and IVDUs[26] and have demonstrated both a significantly high rate of late deep infections and poor outcomes. In a systematic review of 722 THAs from 25 research projects, Enayatollahi et al[27] reported that PJIs occurred with far greater regularity in HIV-infected patients with haemophilia than in patients with HIV alone. The rates of PJI were 10.98% and 2.28%, respectively. However, the incidence of PJI in an era before HAART was as dramatic as 50%.[27] A decreased incidence

of infections in THA in HIV-infected patients has coincided with the introduction of HAART.[21,27]

Pre-HAART era

HIV-infected patients not receiving HAART have demonstrated increased risks of adverse events. Parvizi et al[28] found a high rate of complications in HIV-positive patients undergoing THA in which 80% of participants were not receiving HAART. This included 29% resulting in PJIs.[27] The average CD4+ for the patients with PJI compared to the study population as a whole was 239 cells/mm³ and 523 cells/mm³, respectively.[27] Similarly, Lehman et al[26] found a PJI rate of 14.3% in their HIV-positive patients for THA, none of whom were receiving HAART.

HAART era

Several studies have shown equivocal functional outcomes in HIV-positive patients controlled using HAART when compared to HIV-negative controls. In 2014, Graham et al[29] reported no cases, either early (< 6 weeks) or late (> 6 weeks), of superficial or deep infections, dislocations or venous thrombotic events in 43 THAs performed in 29 HIV-positive patients. This series also reported significant functional gains made post-operatively with significant improvements in the Harris Hip Scores. Naziri et al[30] compared the outcomes of THA in 9275 HIV-infected patients with THA with those of 2.7 million uninfected patients from the Nationwide Inpatient Sample in the USA from 1998 to 2010. HIV-infected patients had rates of major and minor complications of 2.9% and 5.2% respectively, which significantly outweighed the respective rates of 2.7% and 4.8% in non-infected patients.[30] Additionally, an extended length of hospital stay was also noted in the HIV-infected cohort.[30]

In a systematic review of 6.5 million joints included in 21 articles, Dimitriou et al[16] reported that the incidence of PJI in HIV-infected patients was 7.6% and was significantly greater than in non-infected THA, where the rate was found to be 3.3%. The complication rates in these papers ranged from 0% to 46%.[16]

Sadoghi et al[31] analysed worldwide registry data from Sweden, Norway, Finland, Denmark, Australia, and New Zealand to highlight that aseptic loosening was the most common cause of revision in THA and accounted for 55.7% of revision THAs. The third most common reason for revision was PJI.[31] HIV does not seem to contribute to the prevalence of aseptic loosening.[16,21]

The survival rate of THA in HIV-infected patients is comparable with non-HIV-infected patients at one and five years post-operatively.[16] In an article evaluating prosthesis longevity at 10 years, Issa et al[32] concluded that no differences in survival existed between HIV-infected and non-infected patients. Novikov et al[33] reported that the vast majority (80%) of revision THA occurred within one year post-operatively, but that ultimately the revision rate was comparable with non-infected patients in their long-term review.[16] It can be concluded that although functional outcomes for HIV-positive patients on HAART are equivalent to HIV-uninfected patients, a higher risk for PJI exists.

Elective surgery thresholds

Due to the increased demand for THA and the pandemic nature of HIV, it is imperative to consider whether thresholds should be advised for elective THA. A retrospective study by King, et al[23] comparing 30-day post-operative THA mortality in the USA observed that mortality was higher among 1641 HIV-positive patients compared with 3282 HIV-negative controls (3.4% vs. 1.6%). This study found a higher mortality in the HIV-positive group when compared to the control, regardless of CD4+, although a lower CD4+ was associated with higher mortality.[23]

A threshold of CD4+ of 200 cells/mm^3, which correlates with an overriding risk of major post-operative complications including PJI, has been postulated but has gone unproven.[16,21] There is strong evidence to support earlier post-operative failures in HIV-positive patients, especially those with poor disease control.[21] Serum markers should be routinely followed up as infection remains a significant risk, especially if the CD4+ decreases.[21,34] Most articles did not correlate the incidence of complications with CD4+ rigidly or routinely. Dimitriou et al[16] recommended that THA could be performed in HIV-infected patients safely irrespective of the CD4+ count. Shah et al,[21] however, argued that safe elective THA may demand a CD4+ in excess of 400 cells/mm^3.

The importance of pre-operative VL may supersede that of CD4+. A high VL may indicate treatment failure and demand referral to an infectious disease specialist. In a retrospective study of over 5000 HIV-infected patients it was reported that a VL > 30,000 copies/mL was associated with a three-fold increased risk of post-operative complications.[22] Shah et al,[21] in their systematic review, recommended a VL < 50 copies/mL prior to elective surgery. HAART should be continued in all patients and strict compliance is essential. Non-compliance or treatment failure must be considered if follow-up investigations reveal dwindling CD4+ and/or rising VL.

Recommendations

1. All patients eligible for THA, especially those with unknown aetiology, should be sent for routine HIV screening.
2. All HIV-positive patients for THA should be initiated on HAART if not on pre-existing treatment.
3. HIV is a multisystemic disease and infected patients are at increased risk for medical co-morbidities which must be assessed and optimized pre-operatively.
4. If a CD4+ and VL have not been performed within three months prior to THA, these serum markers should be repeated.
5. AIDS patients with CD4+ < 200 cells/mm^3 should be initiated on antibiotic prophylaxis to avoid perioperative infections.
6. HIV-infected patients compliant on HAART for at least 6–8 weeks with VL > 1000 copies/mL or a decrease in VL of less than one *log* from baseline measurement are failing treatment and should be referred to an infectious disease specialist physician.
7. Consideration to postpone HIV-positive patients for elective THA will allow for immune reconstitution with a CD4+ > 200 cells/mm^3 and may prevent post-operative complications.

EFORT open reviews

AUTHOR INFORMATION

Arthroplasty Unit, Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), Johannesburg, South Africa

Correspondence should be sent to: Jurek Rafal Tomasz Pietrzak, Department of Orthopaedics, University of the Witwatersrand, 7 York Road, Parktown, South Africa.
Email: jrtpietrzak@yahoo.com

REFERENCES

1. UNAIDS factsheet, July 2018. https://www.aidsinfo.unaids.org (date last accessed 10 April 2019).

2. Pharris A, Stengaard A, Amato-Gauci AJ, Catchpole M, Croxford S, Dara M, et al. *European Center for Disease Prevention and Control (ECDC) HIV/AIDS surveillance in Europe 2018–2017 data*. World Health Organization, 2018. https://ecdc.europa.eu/en/publications-data/hivaids-surveillance-europe-2018-2017-data (date last accessed 10 April 2019).

3. Public Health England. HIV in the UK, 2016 report. https://www.gov.uk/government/publications/hiv-in-the-united-kingdom (date last accessed 10 April 2019).

4. NJR Editorial Board. National Joint Registry 15th Annual Report 2018. Published 25 September 2018. https://www.hqip.org.uk/resource/national-joint-registry-15th-annual-report-2018/ (date last accessed 10 April 2019).

5. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am* 2007;89:780–785.

6. Kurtz SM, Lau EC, Ong KL, Adler EM, Kolisek FR, Manley MT. Which clinical and patient factors influence the national economic burden of hospital readmissions after total joint arthroplasty? *Clin Orthop Relat Res* 2017;475:2926–2937.

7. Natshara KM, Shelton TJ, Meehan JP, Lum ZC. Mortality during total hip periprosthetic joint infection. *J Arthroplasty* 2019;34(7S):S337–342.

8. Beam E, Osmon D. Prosthetic joint infection update. *Infect Dis Clin North Am* 2018;32:843–859.

9. Eka A, Chen AF. Patient-related medical risk factors for periprosthetic joint infection of the hip and knee. *Ann Transl Med* 2015;3:233.

10. Edwards PK, Mears SC, Stambough JB, Foster SE, Barnes CL. Choices, compromises, and controversies in total knee and total hip arthroplasty modifiable risk factors: what you need to know. *J Arthroplasty* 2018;33:3101–3106.

11. Zainul-Abidin S, Amanatullah DF, Anderson MB, et al. General assembly, prevention, host related general: proceedings of International Consensus on Orthopedic Infections. *J Arthroplasty* 2019;34:S13–S35.

12. Permpalung N, Ungprasert P, Summachiwakij S, Leeaphorn N, Knight EL. Protease inhibitors and avascular necrosis: a systematic review and meta-analysis. *Int J Antimicrob Agents* 2014;44:93–95.

13. Mehta P, Nelson M, Brand A, Boag F. Avascular necrosis in HIV. *Rheumatol Int* 2013;33:235–238.

14. Rothman MS, Bessesen MT. HIV infection and osteoporosis: pathophysiology, diagnosis, and treatment options. *Curr Osteoporos Rep* 2012;10:270–277.

15. Morse CG, Mican JM, Jones EC, et al. The incidence and natural history of osteonecrosis in HIV-infected adults. *Clin Infect Dis* 2007;44:739–748.

16. Dimitriou D, Ramokgopa M, Pietrzak JRT, van der Jagt D, Mokete L. Human immunodeficiency virus infection and hip and knee arthroplasty. *JBJS Rev* 2017;5:e8.

17. Libman H, Bartlett JG, Bloom A. Surgical issues in HIV infection. UpToDate Literature review current through: Oct 2018. https://www.uptodate.com/contents/surgical-issues-in-hiv-infection/ (date last accessed 7 November 2018)

18. Fletcher CV, Bartlett JG, Sax PE, Mitty J. Overview of antiretroviral agents used to treat HIV. UpToDate Literature review current through: Oct 2018. https://www.uptodate.com/contents/overview-of-antiretroviral-agents-used-to-treat-hiv/ (date last accessed 7 November 2018)

19. Meintjes G, Moorhouse MA, Carmona S, et al. Adult antiretroviral therapy guidelines 2017. *South Afr J HIV Med* 2017;18:776.

20. Barnhart M, Shelton JD. ARVs: the next generation. Going boldly together to new frontiers of HIV treatment. *Glob Health Sci Pract* 2015;3:1–11.

21. Shah KN, Truntzer JN, Touzard Romo F, Rubin LE. Total joint arthroplasty in patients with human immunodeficiency virus. *JBJS Rev* 2016;4:e1.

22. Horberg MA, Hurley LB, Klein DB, et al. Surgical outcomes in human immunodeficiency virus-infected patients in the era of highly active antiretroviral therapy. *Arch Surg* 2006;141:1238–1245.

23. King JT Jr, Perkal MF, Rosenthal RA, et al. Thirty-day postoperative mortality among individuals with HIV infection receiving antiretroviral therapy and procedure-matched, uninfected comparators. *JAMA Surg* 2015;150:343–351.

24. Mdodo R, Frazier EL, Dube SR, et al. Cigarette smoking prevalence among adults with HIV compared with the general adult population in the United States: cross-sectional surveys. *Ann Intern Med* 2015;162:335–344.

25. Ragni MV, Crossett LS, Herndon JH. Postoperative infection following orthopaedic surgery in human immunodeficiency virus-infected hemophiliacs with CD4 counts < or = 200/mm³. *J Arthroplasty* 1995;10:716–721.

26. Lehman CR, Ries MD, Paiement GD, Davidson AB. Infection after total joint arthroplasty in patients with human immunodeficiency virus or intravenous drug use. *J Arthroplasty* 2001;16:330–335.

27. Enayatollahi MA, Murphy D, Maltenfort MG, Parvizi J. Human immunodeficiency virus and total joint arthroplasty: the risk for infection is reduced. *J Arthroplasty* 2016;31:2146–2151.

28. Parvizi J, Sullivan TA, Pagnano MW, Trousdale RT, Bolander ME. Total joint arthroplasty in human immunodeficiency virus-positive patients: an alarming rate of early failure. *J Arthroplasty* 2003;18:259–264.

29. Graham SM, Lubega N, Mkandawire N, Harrison WJ. Total hip replacement in HIV-positive patients. *Bone Joint J* 2014;96-B:462–466.

30. Naziri Q, Boylan MR, Issa K, Jones LC, Khanuja HS, Mont MA. Does HIV infection increase the risk of perioperative complications after THA? A nationwide database study. *Clin Orthop Relat Res* 2015;473:581–586.

31. Sadoghi P, Liebensteiner M, Agreiter M, Leithner A, Böhler N, Labek G. Revision surgery after total joint arthroplasty: a complication-based analysis using worldwide arthroplasty registers. *J Arthroplasty* 2013;28:1329–1332.

32. Issa K, Naziri Q, Rasquinha V, Maheshwari AV, Delanois RE, Mont MA. Outcomes of cementless primary THA for osteonecrosis in HIV-infected patients. *J Bone Joint Surg Am* 2013;95:1845–1850.

33. Novikov D, Anoushiravani AA, Chen KK, Wolfson TS, Snir N, Schwarzkopf R. Total hip arthroplasty in human immunodeficiency virus-positive patients: a concise follow-up at 10 to 14 years. *J Arthroplasty* 2019;34:522–526.

34. Lin CA, Kuo AC, Takemoto S. Comorbidities and perioperative complications in HIV-positive patients undergoing primary total hip and knee arthroplasty. *J Bone Joint Surg Am* 2013;95:1028–1036.

35. Center for Disease Prevention and Control (CDC). HIV surveillance report: diagnoses of HIV infection in the United States and dependent areas, 2017; vol. 29. https://www.cdc.gov/hiv/pdf/library/reports/surveillance/cdc-hiv-surveillance-report-2017-vol-29.pdf (date last accessed 10 April 2019).

36. WHO. Consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection. Recommendations for a public health approach. Second ed. World Health Organization, 2016. https://www.who.int/hiv/pub/guidelines/ARV2018update/en/ (date last accessed 7 November 2018).

37. Saag MS, Benson CA, Gandhi RT, et al. Antiretroviral drugs for treatment and prevention of HIV infection in adults: 2018 recommendations of the international antiviral society-USA panel. *JAMA* 2018;320:379–396.

38. Waters L, Ahmed N, Angus B, Boffito M, Bower M, Churchill D, et al. British HIV Association (BHIVA) guidelines for the treatment of HIV-1-positive adults with antiretroviral therapy 2015 (2016 interim update). https://www.bhiva.org/file/RVYKzFwyxpgil/treatment-guidelines-2016-interim-update.pdf (accessed 20 May 2019).

39. Lubega N, Mkandawire NC, Sibande GC, Norrish AR, Harrison WJ. Joint replacement in Malawi: establishment of a national joint registry. *J Bone Joint Surg Br* 2009;91:341–343.

40. Tornero E, García S, Larrousse M, et al. Total hip arthroplasty in HIV-infected patients: a retrospective, controlled study. *HIV Med* 2012;13:623–629.

41. Capogna BM, Lovy A, Blum Y, Kim SJ, Felsen UR, Geller DS. Infection rate following total joint arthroplasty in the HIV population. *J Arthroplasty* 2013;28:1254–1258.

42. Falakassa J, Diaz A, Schneiderbauer M. Outcomes of total joint arthroplasty in HIV patients. *Iowa Orthop J* 2014;34:102–106.

43. Snir N, Wolfson TS, Schwarzkopf R, et al. Outcomes of total hip arthroplasty in human immunodeficiency virus-positive patients. *J Arthroplasty* 2014;29:157–161.

44. Lin CA, Takemoto S, Kandemir U, Kuo AC. Mid-term outcomes in HIV-positive patients after primary total hip or knee arthroplasty. *J Arthroplasty* 2014;29:277–282.