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HIV Seroprevalence and Perioperative Outcomes in Adolescents and Young Adults Undergoing Posterior Instrumented Correction of Scoliosis: A Retrospective Cohort Study from a South African Tertiary Referral Centre

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ABSTRACT

Background: *HIV infection has historically been regarded as a risk factor for adverse surgical outcomes, but contemporary evidence from the antiretroviral therapy (ART) era suggests that well-controlled HIV infection may not independently increase perioperative morbidity. Data specific to paediatric and adolescent spinal deformity surgery in high HIV-burden settings remain scarce.*

Objectives: *To determine the seroprevalence of HIV among adolescents and young adults undergoing posterior instrumented scoliosis correction at a South African tertiary referral centre, and to describe demographic, radiographic, and perioperative characteristics according to HIV status.*

Methods: *Consecutive adolescents and young adults undergoing primary posterior instrumented spinal fusion for scoliosis between January 2015 and February 2022 at Chris Hani Baragwanath Academic Hospital were identified from a prospectively maintained institutional spinal deformity database. HIV status was determined from routine preoperative serology. Demographic, radiographic, and perioperative variables were compared between HIV-positive and HIV-negative patients using Fisher's exact test and the Mann–Whitney U test, as appropriate. Given the small number of HIV-positive patients, between-group comparisons were considered exploratory and hypothesis-generating.*

Results*: Forty-three patients met the inclusion criteria (mean age 15.5 ± 3.5 years, range 11–30 years; 37 female [86.0%], 6 male [14.0%]). Two patients (4.7%; 95% CI 0.57–15.81%) were HIV-positive. Baseline Cobb angle (66.1 ± 16.6° versus 70° and 80°, p = 0.38), preoperative haemoglobin (13.61 ± 1.25 versus 13.7 and 14.6 g/dL, p = 0.44), postoperative haemoglobin (10.81 ± 1.48 versus 11.7 and 11.8 g/dL, p = 0.19), and estimated blood loss (746.8 ± 318.8 versus 350 and 500 mL, p = 0.14) did not differ significantly between HIV-negative and HIV-positive patients. Documented medical comorbidity was more frequent among HIV-positive patients (2/2, 100%) than HIV-negative patients (6/41, 14.6%; p = 0.031), although this should be interpreted cautiously given the small subgroup. Overall, 7 of 43 patients (16.3%) experienced a postoperative complication; none occurred in the HIV-positive subgroup.*

Conclusions: *In this cohort, HIV seroprevalence among adolescents undergoing scoliosis correction was 4.7%, lower than the estimated general-population prevalence in South Africa, likely reflecting careful preoperative patient selection. HIV-positive patients experienced perioperative outcomes comparable with HIV-negative patients. These preliminary, hypothesis-generating findings support the view that well-controlled HIV infection, in isolation, should not be regarded as a contraindication to elective spinal deformity surgery; larger prospective multicentre studies incorporating immunological and virological variables are needed.*

Keywords
Human immunodeficiency virus, Adolescent idiopathic scoliosis, Posterior spinal fusion, Perioperative outcomes, surgical site infection, Sub-Saharan Africa.

List of Abbreviations
AIS: Adolescent idiopathic scoliosis, ART: Antiretroviral therapy, AYA: Adolescents and young adults, HIV: Human immunodeficiency virus, PLHIV: People living with HIV (PLHIV), SRS: Scoliosis Research Society (SRS), SSI: Surgical Site Infection.

Introduction
Human immunodeficiency virus (HIV) remains one of the leading causes of chronic disease worldwide despite remarkable advances in prevention and treatment. According to the Joint United Nations Programme on HIV/AIDS (UNAIDS), an estimated 39.9 million people were living with HIV globally in 2023, with sub-Saharan Africa accounting for approximately two-thirds of all infections [1]. South Africa continues to bear the world's largest HIV epidemic, with nearly 8 million people living with HIV and one of the largest antiretroviral therapy (ART) programmes worldwide [1,2]. The widespread implementation of combination ART has transformed HIV infection into a chronic, manageable disease, resulting in substantial improvements in survival among children infected perinatally. Consequently, increasing numbers of adolescents and young adults (AYA) living with HIV are surviving into adulthood and are presenting with surgical conditions requiring elective orthopaedic intervention [2-4].

Adolescent idiopathic scoliosis (AIS) is the most common structural spinal deformity in childhood and adolescence, accounting for approximately 70-80% of all scoliosis cases [5]. The condition is defined as a three-dimensional spinal deformity characterised by a coronal Cobb angle ≥10° with vertebral rotation in otherwise healthy individuals without congenital, neuromuscular, or syndromic abnormalities [5,6]. Although the prevalence of AIS is estimated at 2–3% of adolescents, only a minority develop progressive deformities requiring operative correction [5,7]. Progressive scoliosis may result in chronic pain, cosmetic deformity, impaired pulmonary function, reduced exercise capacity, psychosocial distress, and diminished health-related quality of life, emphasising the importance of timely diagnosis and appropriate management [6-8].

Treatment of AIS is guided by skeletal maturity, curve magnitude, and the likelihood of progression. Observation is appropriate for mild deformities, whereas brace treatment is recommended for skeletally immature patients with moderate progressive curves. Posterior spinal fusion with segmental instrumentation remains the gold standard for severe or progressive deformities exceeding 45–50°, achieving reliable deformity correction and durable functional improvement [8-10]. Advances in pedicle screw instrumentation, intraoperative neuromonitoring, blood conservation techniques, enhanced recovery protocols, and multidisciplinary perioperative care have significantly improved the safety and effectiveness of spinal deformity surgery over the past two decades [9-11].

Despite these advances, posterior spinal fusion remains one of the most technically demanding procedures in orthopaedic surgery and is associated with considerable physiological stress. Potential complications include excessive blood loss, neurological injury, implant-related failure, proximal junctional kyphosis, pseudarthrosis, and surgical site infection (SSI) [11-13]. Although postoperative infection following AIS surgery is uncommon, it remains one of the most serious complications because it frequently requires repeated surgical debridement, prolonged antimicrobial therapy, delayed rehabilitation, and occasionally implant removal [12,13]. Identifying patient-related risk factors for perioperative complications therefore remains fundamental to optimising outcomes.

Historically, HIV infection has been considered a potential risk factor for adverse surgical outcomes because of impaired cellular immunity, chronic systemic inflammation, nutritional deficiencies, and susceptibility to opportunistic infection [14]. Early orthopaedic studies conducted before widespread ART availability reported increased rates of wound complications, postoperative infection, prolonged hospitalisation, and mortality among HIV-positive patients undergoing major orthopaedic procedures [15]. These observations resulted in considerable caution regarding elective surgery in patients living with HIV.

However, the modern treatment era has substantially altered the natural history of HIV infection. Contemporary evidence suggests that well-controlled HIV infection, particularly among patients receiving effective ART with suppressed viral loads and preserved CD4 cell counts, may not independently increase postoperative complications following elective orthopaedic procedures [16,17]. Instead, perioperative risk appears to be more closely associated with immune suppression, uncontrolled viraemia, nutritional status, and associated medical comorbidities than HIV serostatus alone [17,18]. Nevertheless, much of the available literature relates to adult arthroplasty, fracture surgery, or trauma populations, while evidence relating specifically to spinal deformity surgery remains sparse.

The relationship between HIV infection and scoliosis surgery is particularly poorly understood in adolescents and young adults. Existing spine literature has predominantly focused on degenerative spinal disease, spinal infections, or traumatic injuries in adults, whereas HIV-positive adolescents undergoing elective deformity correction have received little attention [11,19]. Furthermore, most published studies originate from high-income countries where HIV prevalence is substantially lower than in Southern Africa, limiting their generalisability to regions with endemic HIV infection.

South Africa provides a unique environment in which to investigate this knowledge gap. Universal HIV testing and widespread ART availability have resulted in increasing numbers of adolescents living with well-controlled HIV presenting for elective surgical procedures, including spinal deformity correction. Understanding

the prevalence of HIV within scoliosis surgical populations and its potential influence on perioperative outcomes is therefore increasingly relevant for spine surgeons practising in high HIV-burden settings. Such information may improve preoperative counselling, perioperative optimisation, multidisciplinary decision-making, and healthcare planning.

Hence, this study aims to determine the seroprevalence of HIV among adolescents and young adults undergoing posterior scoliosis correction at a South African tertiary referral centre. The secondary objectives were to describe demographic, radiographic, surgical, and perioperative characteristics according to HIV status. Given the small number of HIV-positive patients identified, comparisons between groups were considered exploratory and intended to generate hypotheses rather than establish causal relationships. We hypothesised that HIV seroprevalence within this cohort would reflect the underlying epidemiology of South African adolescents and that, in the era of contemporary ART and modern perioperative care, HIV infection alone would not be associated with clinically meaningful differences in early perioperative outcomes.

Materials and Methods

Study Design and Setting

This retrospective observational cohort study was conducted at the Spine Unit of Chris Hani Baragwanath Academic Hospital (CHBAH), a major tertiary referral centre affiliated with the University of the Witwatersrand, Johannesburg, South Africa. Consecutive adolescents and young adults undergoing posterior instrumented scoliosis correction between 1 January 2015 and 28 February 2022 were identified from a prospectively maintained institutional spinal deformity database.

The study was designed and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies. Ethical approval was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (Protocol No. M190943).

Patient Selection

All consecutive adolescents and young adults who underwent primary posterior spinal fusion for scoliosis during the study period were screened for eligibility. Adolescence and young adulthood were defined according to the World Health Organization age classification and institutional clinical practice.

Patients were eligible if they underwent posterior instrumented spinal fusion for scoliosis between January 2015 and February 2022, had complete operative records available within the institutional database, documented preoperative radiographs suitable for measurement of the major Cobb angle and had HIV serological results available from routine preoperative investigations.

Patients undergoing revision deformity surgery, anterior-only procedures, or surgery for acute traumatic spinal deformity were excluded. Cases with incomplete operative documentation or unavailable HIV serostatus were also excluded from comparative analyses.

A total of 43 consecutive patients satisfied the eligibility criteria and constituted the final study cohort. Patient selection was consecutive to minimise selection bias and to provide an accurate representation of the scoliosis population managed at this tertiary referral centre.

Preoperative Assessment

All patients underwent standard multidisciplinary preoperative assessment according to institutional protocols. Clinical evaluation included demographic information, detailed medical history, physical examination, neurological assessment, and anaesthetic review. Routine laboratory investigations included complete blood count, renal function, coagulation profile, and HIV serology performed as part of standard preoperative screening in accordance with South African national guidelines.

Standing posteroanterior and lateral full-length spinal radiographs were obtained for all patients. Radiographic evaluation included measurement of the major Cobb angle using the Cobb method, assessment of sagittal alignment, and Lenke curve classification where appropriate. Flexibility assessment was performed using side-bending radiographs or prone radiographs obtained under general anaesthesia (p-UGA) according to surgeon preference and curve characteristics. Surgical indications generally included progressive deformity despite conservative treatment, major curves exceeding approximately 45-50°, unacceptable cosmetic deformity, or functional impairment.

HIV Assessment

HIV status was determined from routine preoperative serological testing documented within institutional medical records. HIV-positive patients were identified from the institutional surgical database and verified through review of electronic and paper-based clinical records.

Due to the retrospective nature of the database, detailed HIV-specific clinical variables including CD4 lymphocyte count, plasma HIV viral load, duration of infection, antiretroviral therapy regimen, treatment adherence, and World Health Organization clinical stage were not consistently available and therefore could not be included in the present analysis. Consequently, HIV infection was analysed as a binary clinical variable (positive or negative), and no assessment of disease severity or virological control was possible.

Data Collection

Clinical data were extracted from the institutional spinal deformity database and verified through review of operative records, anaesthetic charts, radiographs, laboratory reports, and inpatient clinical notes. The following variables were collected; age, sex, medical comorbidities, HIV serostatus, preoperative haemoglobin and postoperative haemoglobin concentration. Radiographic variables such as Lenke curve classification, preoperative major

Cobb angle, curve flexibility assessment and radiographic classification were also collected. Data extraction was performed using a standardised collection form to ensure consistency across all patients.

Outcome Measures

The primary outcome was the seroprevalence of HIV among adolescents and young adults undergoing scoliosis correction during the study period.

Secondary outcomes included descriptive comparison of perioperative characteristics according to HIV status, preoperative major Cobb angle, preoperative haemoglobin concentration, postoperative haemoglobin concentration, estimated intraoperative blood loss, operative duration and occurrence of postoperative complications. Postoperative complications were defined as any adverse event documented during the index hospital admission or early postoperative period requiring additional medical or surgical management. Complications included deep surgical site infection, implant-related failure, proximal junctional failure, neurological events, wound complications, or unplanned reoperation.

Given the very small number of HIV-positive patients identified, comparative analyses were considered exploratory and hypothesis-generating rather than confirmatory.

Statistical Analysis

Data were analysed using R software (version 2026.01.0+392). Continuous variables were summarised as means with standard deviations and compared between HIV-positive and HIV-negative patients using the Mann-Whitney U test. Categorical variables were reported as frequencies and percentages and compared using Fisher's exact test. HIV seroprevalence was calculated with an exact 95% confidence interval. Given that only two HIV-positive patients were identified, all between-group comparisons are descriptive and hypothesis-generating; no adjustment for multiple comparisons was applied. A two-sided p-value <0.05 was considered nominally significant.

Results

Patient Demographics and Characteristics

Forty-three adolescents and young adults underwent posterior scoliosis correction during the study period and met inclusion criteria. The mean age was 15.5 ± 3.5 years, and 37 of 43 patients (86.0%) were female. About 25 patients (58.1%) were classified as p-UGA and 18 (41.9%) as normal (Table 1).

Baseline and perioperative characteristics of the HIV-negative (n=41) and HIV-positive (n=2) groups are summarised in Table 1. Age did not differ significantly between groups (p=0.75). Both HIV-positive patients were female, consistent with the overall female predominance of the cohort. A documented comorbidity was present in both HIV-positive patients (100%) compared with 6 of 41 HIV-negative patients (14.6%), a nominally significant difference (Fisher's exact p=0.031).

Table 1: Baseline demographic, radiographic, and perioperative characteristics by HIV status.

Variable	HIV-negative (n=41)	HIV-positive (n=2)	p-value
Age (years) ± mean (SD)	15.5 ±3.5	14;17	0.75
Female sex, n (%)	35 (85.4)	2 (100)	-
Medical Comorbidity, n (%)	6 (14.6)	2 (100)	0.031
Preoperative major Cobb angle ± (SD)	66.1 ±16.6	70; 80	0.38
Preoperative Hb (g/dL)	13.61± 1.25	13.7, 14.6	0.44
Postoperative Hb (g/dL)	10.81± 1.48	11.7, 11.8	0.19
Estimated blood loss (mL)	746.8± 318.8	350; 500	0.14
Any postoperative complication, n (%)	7 (17.1)	0 (0)	1.0

Data are n (%) or mean (SD) Preoperative Cobb angle available for 38/41 HIV-negative and 2/2 HIV-positive patients. ‡Estimated blood loss recorded for 31/41 HIV-negative and 2/2 HIV-positive patients. p-values from Fisher's exact test (categorical variables) or Mann-Whitney U test (continuous variables).

HIV Seroprevalence

Two of the 43 patients were identified as HIV-positive, yielding a seroprevalence of 4.7% (95% CI 0.57–15.81%). Both were female adolescents, aged 14 and 17 years. These HIV-positive patients had a Lenke type 1 curve pattern, with preoperative major Cobb angles of 70° and 80°. Preoperative haemoglobin was 14.6 g/dL and 13.7 g/dL, and postoperative haemoglobin was 11.7 g/dL and 11.8 g/dL. Estimated blood loss was 500 mL and 350 mL, and surgical duration was 4 hours 35 minutes and 6 hours respectively. Neither patient had a postoperative complication (Table 2).

Variable	HIV-positive Patient 1	HIV-positive Patient 2
Age, years	14	17
Sex	Female	Female
Comorbidity present	Yes	Yes
Lenke curve type	1	1
Preoperative major Cobb angle	70°	80°
Preoperative haemoglobin, g/dL	14.6	13.7
Postoperative haemoglobin, g/dL	11.7	11.8
Estimated blood loss, mL	500	350
Surgical duration, h:min	04:35	06:00
Postoperative complication	None	None

Radiographic Characteristics

The distribution of Lenke classifications is shown in Figure 1A. Lenke Type 1 and Type 3 curves were equally represented and comprised the majority of the cohort (16 patients each; 37.2%). Lenke Type 2 deformities accounted for 14.0% of cases (n = 6), whereas Types 5, 4, and 6 were uncommon, representing 7.0%, 2.3%, and 2.3% of the cohort, respectively. This distribution reflects the predominance of thoracic and double-major curve patterns typically encountered in tertiary spinal deformity practice.

Among patients with complete radiographic data, the mean preoperative major Cobb angle was 66.5 ± 16.3° (range, 30°-100°). The distribution of Cobb angles is presented in Figure 1B,

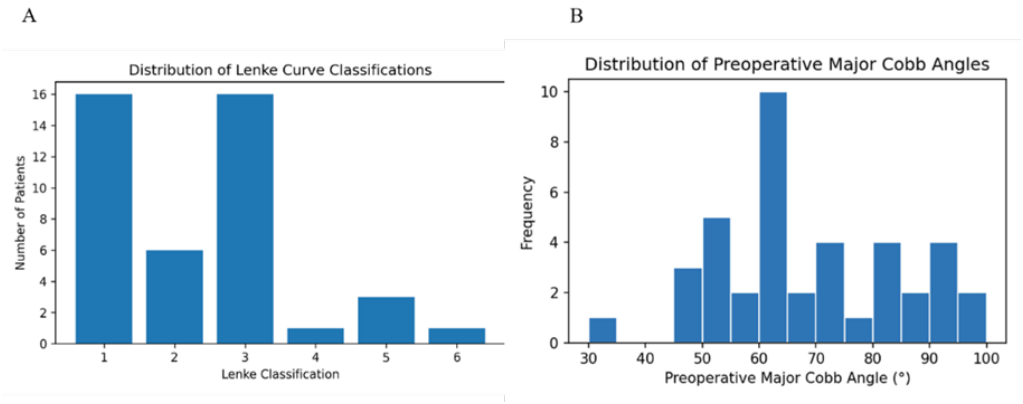

Figure 1A: Distribution of Lenke curve classifications among adolescents and young adults undergoing posterior instrumented scoliosis correction (n = 43). Lenke Type 1 and Type 3 deformities were the most common curve patterns, each accounting for 16 patients (37.2%). Type 2 curves were identified in 6 patients (14.0%), while Types 5, 4, and 6 were less frequent, occurring in 3 (7.0%), 1 (2.3%), and 1 (2.3%) patient, respectively. **B.** Frequency distribution of preoperative major Cobb angles in patients undergoing scoliosis correction surgery. The peak frequency was around 60°, indicating that most patients presented with moderate-to-severe scoliosis requiring operative management.

demonstrating that most patients presented with moderate-to-severe deformity requiring operative correction.

Operative Characteristics

Estimated intraoperative blood loss according to HIV serostatus is illustrated in Figure 2. Considerable variability in blood loss was observed among HIV-negative patients, ranging from approximately 250 mL to 1,600 mL, with a median estimated blood loss of 700 mL. In contrast, the two HIV-positive patients had estimated blood losses of 350 mL and 500 mL, with a median of 425 mL. Although the HIV-positive subgroup demonstrated numerically lower intraoperative blood loss than the HIV-negative group, this difference was not statistically significant (p = 0.14). The wide dispersion of blood loss observed among HIV-negative patients likely reflects heterogeneity in curve severity, surgical complexity, fusion levels, and operative duration. Given the very small number of HIV-positive patients, these findings should be regarded as descriptive and hypothesis-generating rather than indicative of a true association between HIV status and intraoperative blood loss.

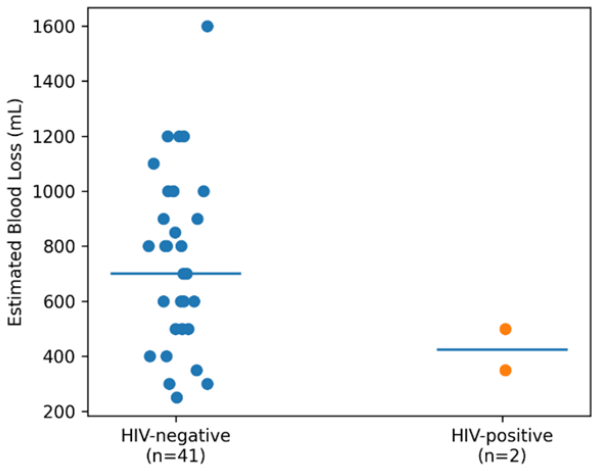

Figure 2: Individual estimated intraoperative blood loss according to HIV serostatus. Each point represents one patient. Horizontal lines indicate the group median. The HIV-positive subgroup comprised two patients. Owing to the very small number of HIV-positive patients, comparisons should be interpreted as descriptive and hypothesis-generating.

Curve Severity and Blood loss

The association between preoperative major Cobb angle and estimated intraoperative blood loss is illustrated in Figure 3. A weak positive trend was observed, indicating that larger preoperative deformities were generally associated with greater intraoperative blood loss. However, substantial inter-patient variability was present, with blood loss ranging from approximately 250 mL to 1,600 mL across the spectrum of curve severity. These findings suggest that while deformity magnitude may contribute to intraoperative blood loss, additional patient- and procedure-related factors also influence perioperative blood loss.

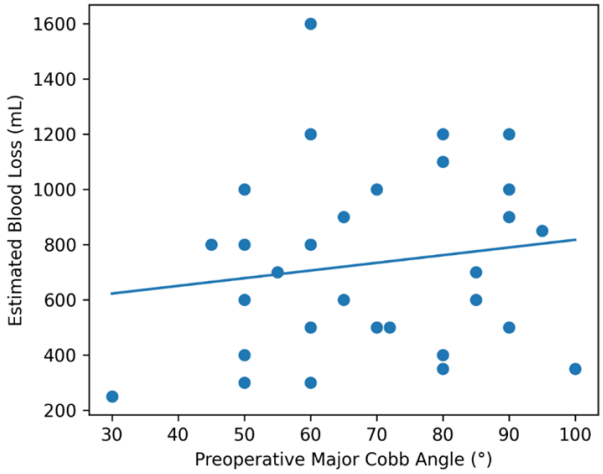

Figure 3: Relationship between preoperative major Cobb angle and estimated intraoperative blood loss in adolescents and young adults undergoing posterior instrumented scoliosis correction. Each point represents an individual patient. The solid line represents the fitted linear regression line. A weak positive relationship was observed, suggesting that patients with larger spinal deformities tended to experience greater

intraoperative blood loss, although considerable variability was evident across the cohort.

Postoperative Complications

Overall, 7 of 43 patients (16.3%) experienced at least one documented postoperative complication. Mechanical complications predominated and included instrumentation failure requiring revision surgery (n = 3) and one case of proximal junctional failure. One patient experienced a false-positive intraoperative neuromonitoring alert without postoperative neurological deficit, while another developed a Koebner phenomenon involving the surgical scar. A single patient developed deep wound infection requiring irrigation, debridement and implant removal. Importantly, no postoperative complications occurred among the HIV-positive patients. All documented complications occurred in HIV-negative individuals.

Discussion

The present study represents one of the first investigations from sub-Saharan Africa to evaluate HIV seroprevalence and perioperative outcomes among adolescents and young adults undergoing posterior instrumented scoliosis correction. Although South Africa has one of the world's highest burdens of HIV infection [20], evidence describing the influence of HIV on spinal deformity surgery remains extremely limited.

This study therefore provides novel data from a tertiary referral centre where both spinal deformity and HIV are frequently encountered. The principal findings were fourfold; first, the prevalence of HIV among patients undergoing scoliosis correction was 4.7%, with two HIV-positive patients identified among 43 consecutive surgical cases. Second, HIV-positive patients demonstrated perioperative outcomes comparable to those of HIV-negative patients, with no statistically significant differences in deformity severity, perioperative haemoglobin concentration, estimated intraoperative blood loss, or early postoperative complications. Third, the study cohort was characterised by the expected demographic profile of surgically treated adolescent spinal deformity, including a predominance of female patients, moderate-to-severe curve magnitude, and Lenke Type 1 and Type 3 deformities. Finally, although substantial variability in intraoperative blood loss was observed across the cohort, HIV infection was not associated with adverse short-term surgical outcomes in this carefully selected patient population.

The increasing life expectancy of people living with HIV has transformed the epidemiology of orthopaedic disease worldwide. Since the widespread implementation of combination ART, HIV has evolved from a rapidly progressive, fatal disease into a chronic condition compatible with near-normal life expectancy for many patients receiving effective treatment. Consequently, increasing numbers of adolescents and young adults living with HIV are presenting with musculoskeletal conditions requiring complex elective orthopaedic procedures, including spinal deformity correction. Contemporary orthopaedic practice has therefore shifted from considering HIV infection an absolute contraindication to major reconstructive surgery, towards individualised perioperative risk assessment based on immune function, viral suppression, nutritional status, and comorbidity burden, rather than HIV serostatus alone. Recent reviews emphasise that patients receiving effective ART with preserved immune function generally experience perioperative outcomes approaching those of HIV-negative individuals, provided appropriate multidisciplinary perioperative optimisation is undertaken [5,21,22].

The HIV seroprevalence of 4.7% observed in the present study appears lower than the estimated prevalence within the general South African adult population; according to the latest national estimates, approximately 13-14% of South Africans are living with HIV, with prevalence varying according to age, sex, and geographical region [2,4]. However, direct comparison between our findings and population-based prevalence estimates should be made cautiously. Patients undergoing elective scoliosis correction represent a highly selected subgroup referred to tertiary spinal deformity units after extensive multidisciplinary assessment. Individuals with uncontrolled HIV infection, severe immunosuppression, active opportunistic infections, or poorly controlled medical comorbidities are unlikely to proceed to complex posterior spinal fusion until adequately optimised. Consequently, the lower HIV prevalence observed within this surgical cohort probably reflects careful patient selection rather than reduced HIV prevalence among adolescents requiring scoliosis surgery.

The identification of only two HIV-positive patients also reflects the relative rarity of spinal deformity surgery among South African adolescents, despite the country's large burden of HIV infection. Surgical correction of scoliosis requires highly specialised multidisciplinary services, advanced spinal instrumentation, and considerable perioperative resources that remain concentrated within relatively few tertiary referral centres. Previous South African studies have highlighted prolonged waiting times, delayed referral pathways, and limited access to specialised spinal deformity services, all of which influence the epidemiology of patients ultimately undergoing surgery [23]. Consequently, the present cohort is likely representative of patients considered sufficiently fit to undergo major reconstructive surgery, rather than the broader population of adolescents living with HIV.

Importantly, neither HIV-positive patient experienced a postoperative complication during the study period. Although this observation should not be interpreted as evidence that HIV confers no additional perioperative risk, it is consistent with the growing body of literature demonstrating that well-controlled HIV infection is not independently associated with poor outcomes following elective orthopaedic surgery. Earlier reports published before the widespread availability of ART consistently described increased rates of postoperative infection, delayed wound healing, and prolonged hospitalisation among HIV-positive patients, particularly those with advanced immunodeficiency [6]. However, more recent studies suggest that postoperative risk is more closely associated with immunological status, viral suppression, and the presence of medical comorbidities than with HIV serostatus itself

[5,6,22]. This evolving understanding has resulted in substantial changes in perioperative management and surgical decision-making for patients living with HIV.

Evidence specific to spinal surgery remains comparatively limited. Most contemporary studies evaluating HIV and orthopaedic outcomes have focused on total hip arthroplasty, total knee arthroplasty, or trauma surgery rather than spinal deformity correction [17,24]. Existing spinal literature primarily comprises adult degenerative conditions and database studies, which frequently include heterogeneous patient populations with variable disease severity and incomplete information regarding HIV control. Consequently, there remains a paucity of evidence describing outcomes following scoliosis correction in adolescents and young adults living with HIV. The present study therefore contributes important preliminary data to an area where high-quality prospective evidence remains scarce.

The demographic characteristics of the study cohort closely resemble those reported in contemporary international scoliosis series. Female patients accounted for over 80% of the study population, consistent with the recognised female predominance among adolescents requiring operative treatment for idiopathic scoliosis [5]. The reasons underlying this sex disparity remain incompletely understood but probably reflect differences in curve progression during skeletal growth, hormonal influences, and genetic susceptibility [25]. Recent reviews continue to demonstrate that although mild adolescent idiopathic scoliosis occurs with similar frequency between sexes, progressive deformities requiring operative correction occur substantially more frequently in females [26]. The mean age at surgery of approximately 15 years similarly corresponds with published international experience, where corrective surgery is generally undertaken following documented progression despite conservative management, and after sufficient skeletal maturity has been achieved [27].

Radiographically, the predominance of Lenke Type 1 and Type 3 deformities observed in this cohort is also consistent with previous surgical series [28,29]. These curve patterns collectively represented almost three-quarters of all patients undergoing surgery and reflect the predominance of structural thoracic and double-major deformities among individuals requiring operative intervention. Contemporary classifications continue to support the Lenke system as the international standard for operative planning because it facilitates reproducible assessment of structural curve patterns, guides fusion-level selection, and improves communication between surgeons [30]. The similarity of our radiographic distribution to previously published cohorts supports the external validity of the present study despite its relatively small sample size.

The mean preoperative major Cobb angle of 66.5° confirms that most patients presented with moderate-to-severe spinal deformities requiring surgical correction according to internationally accepted indications. Current recommendations generally support operative treatment for progressive curves exceeding 45-50°, particularly in skeletally immature patients or those with documented progression despite bracing [12]. The larger deformities observed within our cohort likely reflect delayed presentation to specialist spinal services, an issue frequently encountered throughout low- and middle-income countries. Delays in referral may result from limited awareness of scoliosis among primary healthcare providers, restricted access to specialist assessment, prolonged surgical waiting lists, and resource limitations affecting tertiary spinal services. Similar observations have recently been reported in South African spinal units, where delayed access to definitive surgical treatment remains a significant challenge despite ongoing improvements in healthcare delivery [23].

Perioperative blood loss remains one of the principal challenges associated with posterior scoliosis correction. In the present study, estimated intraoperative blood loss demonstrated considerable inter-patient variability, ranging from approximately 250 mL to 1,600 mL. Such variability is expected and reflects the multifactorial determinants of blood loss during spinal deformity correction. Previous studies have consistently demonstrated associations between blood loss and curve magnitude, operative duration, number of instrumented vertebral levels, osteotomy use, revision surgery, and patient body habitus [31]. Although our HIV-positive patients experienced numerically lower blood loss than HIV-negative patients, no statistically significant difference was observed, and this finding should not be interpreted as clinically meaningful given the extremely limited sample size.

The observed postoperative decline in haemoglobin concentration was similarly consistent with expectations following extensive posterior spinal fusion. Mean haemoglobin decreased preoperatively, representing an average reduction of approximately 2.8 g/dL. This degree of haemoglobin reduction compares favourably with recent contemporary scoliosis series employing modern blood-conservation strategies, including tranexamic acid administration, controlled hypotensive anaesthesia, meticulous intraoperative haemostasis, and cell-salvage techniques where available [13,32]. The absence of significant differences in perioperative haemoglobin concentrations between HIV-positive and HIV-negative patients further supports the observation that HIV infection itself did not appear to influence short-term physiological recovery following surgery [33].

Another important observation was the apparent relationship between preoperative deformity magnitude and estimated intraoperative blood loss. Although substantial variability was present, larger curves generally required more extensive surgical correction and tended to be associated with greater blood loss [34]. This finding is biologically plausible and has been consistently reported in previous scoliosis literature, where increasing curve magnitude often correlates with longer operative duration, more extensive soft-tissue dissection, and increased instrumentation requirements [34]. Nevertheless, deformity severity alone cannot fully explain perioperative blood loss, emphasising the contribution of operative technique, anaesthetic management, and patient-specific factors. Future studies incorporating multivariable

regression analysis would help determine the relative contribution of these variables within South African practice.

Postoperative Complications and Early Clinical Outcomes

The overall postoperative complication rate in the present study was 16.3%, with seven of the 43 patients experiencing at least one documented adverse event. Instrumentation failure requiring revision surgery was the most frequent complication, accounting for three cases, while isolated cases of deep surgical site infection, proximal junctional failure, a false-positive intraoperative neuromonitoring alert, and a Koebner phenomenon were also observed [35]. Importantly, no postoperative complications occurred among the two HIV-positive patients, although the study was clearly underpowered to detect clinically meaningful differences between groups.

The overall complication profile is comparable with contemporary reports of posterior spinal fusion for adolescent spinal deformity. Modern series generally report overall complication rates ranging from 10% - 25%, depending on patient selection, deformity severity, surgical complexity, duration of follow-up, and the definition of complications included [14]. Early complications are most commonly related to wound infection, implant-related problems, neurological events, and pulmonary complications, whereas mechanical failure and proximal junctional deformity may become more apparent with longer follow-up [14,15,36]. The complication rate observed in the present cohort therefore falls within the expected range for complex spinal deformity surgery performed in specialised centres.

Instrumentation failure represented the most common postoperative complication in our cohort. Mechanical failure following posterior spinal fusion is multifactorial and has been associated with large curve magnitude, inadequate correction, implant-related factors, poor bone quality, pseudarthrosis, and junctional stress. Contemporary studies emphasise that meticulous surgical planning, restoration of appropriate sagittal alignment, and accurate selection of fusion levels remain the principal strategies for reducing mechanical complications after scoliosis correction [26,19]. As our study focused primarily on HIV seroprevalence rather than implant performance, detailed assessment of implant configuration and radiographic alignment was beyond its scope. Nevertheless, future studies should include radiographic parameters such as sagittal vertical axis, pelvic incidence-lumbar lordosis mismatch, and correction rate, to better characterise factors associated with mechanical complications in South African practice.

Infection remains one of the most devastating complications following spinal deformity surgery because it frequently necessitates prolonged antimicrobial therapy, repeated surgical debridement, and, occasionally, implant removal [37]. Several factors influence postoperative infection risk, including operative duration, blood loss, nutritional status, obesity, diabetes mellitus, revision surgery, and perioperative transfusion [38]. Although HIV infection has historically been regarded as an independent risk factor for postoperative infection, more recent evidence indicates that well-controlled HIV infection is not consistently associated with increased surgical site infection when viral suppression is achieved and perioperative optimisation is undertaken [22].

The absence of infection among the HIV-positive patients in the present study should therefore be interpreted within the context of modern HIV management, rather than viewed as unexpected. Both HIV-positive patients underwent elective surgery after routine multidisciplinary assessment and experienced uncomplicated postoperative recovery. However, because only two HIV-positive patients were included, no conclusions regarding comparative infection risk can be drawn. Rather, these findings reinforce the importance of careful preoperative optimisation, multidisciplinary perioperative care, and appropriate patient selection.

HIV and Elective Spinal Surgery

Historically, orthopaedic surgeons were reluctant to undertake complex reconstructive procedures in patients living with HIV because of concerns regarding wound healing, postoperative infection, and implant failure. Many of these concerns originated from studies performed before the widespread availability of effective combination ART, when advanced immunosuppression and opportunistic infections were common [39]. Over the past two decades, however, the treatment landscape has changed dramatically. Contemporary international guidelines increasingly recommend that surgical decision-making should be guided by immune function, viral suppression, and overall physiological fitness, rather than HIV serostatus alone [40].

Our findings support this evolving paradigm. Despite the high prevalence of HIV in South Africa, the HIV-positive patients included in this study demonstrated perioperative outcomes comparable with those of HIV-negative patients. Although the study was not powered to identify statistically significant differences, the absence of excess morbidity suggests that carefully selected adolescents receiving appropriate multidisciplinary care may safely undergo posterior spinal fusion. This observation aligns with recent systematic reviews demonstrating that postoperative outcomes in patients receiving effective ART are substantially better than those reported in historical cohorts [22].

An important limitation of the present study is the absence of HIV-specific clinical variables, including CD4 lymphocyte count, HIV viral load, duration of antiretroviral therapy, treatment adherence, and World Health Organization clinical stage. These variables have consistently been shown to influence perioperative outcomes more strongly than HIV serostatus alone. Future studies should therefore incorporate detailed immunological and virological data to enable more comprehensive perioperative risk stratification.

Clinical Implications

Although the HIV-positive subgroup was small, the findings have practical implications for spinal surgeons practising in regions with a high HIV burden. Elective scoliosis correction should not be denied solely because a patient is HIV-positive.

Instead, comprehensive preoperative optimisation should include confirmation of effective antiretroviral therapy, assessment of viral suppression, evaluation of immune status, nutritional optimisation, and multidisciplinary perioperative planning involving infectious diseases specialists, anaesthetists, and rehabilitation teams.

This patient-centred approach is increasingly recommended within international orthopaedic and spine guidelines and reflects the transition towards personalised perioperative care. Contemporary evidence indicates that optimisation of modifiable risk factors including anaemia, malnutrition, smoking, obesity, and uncontrolled medical comorbidities has a greater influence on postoperative outcomes than HIV infection alone [41]. Consequently, HIV should be considered one component of a comprehensive perioperative risk assessment, rather than an isolated determinant of surgical eligibility.

The present findings also highlight the feasibility of performing complex spinal deformity surgery within specialised South African centres despite significant healthcare resource constraints. The favourable outcomes observed among both HIV-positive and HIV-negative patients underscore the value of multidisciplinary perioperative pathways and support continued investment in specialised spinal deformity services throughout sub-Saharan Africa.

Strengths

Several strengths enhance the validity of this study. First, all patients underwent routine HIV testing, ensuring complete ascertainment of HIV serostatus and eliminating misclassification bias. Second, consecutive patient inclusion minimised selection bias and reflects routine clinical practice within a tertiary referral centre. Third, the study provides one of the first descriptions of HIV prevalence among adolescents and young adults undergoing scoliosis surgery in sub-Saharan Africa, addressing an important gap in the literature. Finally, detailed perioperative variables, including deformity severity, blood loss, haemoglobin concentrations, and postoperative complications, allowed comprehensive evaluation of early surgical outcomes.

Limitations

The findings should nevertheless be interpreted within the context of several limitations. Most importantly, only two HIV-positive patients were identified, substantially limiting statistical power and precluding robust comparative analyses. Consequently, all comparisons involving HIV-positive patients should be regarded as exploratory rather than confirmatory.

The retrospective design introduces the possibility of information bias and incomplete data capture. Although perioperative variables were routinely documented, estimated blood loss was unavailable for a proportion of patients, and longer-term patient-reported outcomes were not available. Similarly, detailed radiographic parameters describing sagittal alignment and correction magnitude were not consistently recorded and therefore could not be incorporated into the analysis.

The study was performed at a single tertiary referral centre, which may limit generalisability to institutions with different referral pathways, perioperative protocols, or patient populations. Referral bias is also possible, because patients with poorly controlled HIV infection or severe medical comorbidity may not have been considered suitable candidates for elective deformity correction. Consequently, the findings should not be extrapolated to all patients living with HIV.

Finally, the study evaluated only early perioperative outcomes. Long-term assessment of fusion rates, implant survival, deformity progression, health-related quality of life, functional recovery, and revision surgery is required to determine whether HIV influences longer-term outcomes following scoliosis correction.

Future Directions

Future research should focus on prospective multicentre studies involving larger numbers of HIV-positive patients from high-volume spinal deformity centres across southern Africa. Such collaborations would provide sufficient statistical power to evaluate postoperative complications, implant survival, and patient-reported outcomes while allowing adjustment for potential confounding factors. Collection of detailed HIV-specific variables including viral load, CD4 count, antiretroviral therapy duration, and treatment adherence would permit more refined perioperative risk stratification. Incorporation of validated patient-reported outcome measures, including the Scoliosis Research Society-22r (SRS-22r) and EQ-5D, would further strengthen future investigations by evaluating functional recovery and health-related quality of life alongside traditional surgical outcomes.

Conclusion

In this single-centre cohort of adolescents and young adults undergoing posterior instrumented scoliosis correction, the prevalence of HIV infection was 4.7%. HIV-positive patients demonstrated perioperative outcomes comparable with those of HIV-negative patients, with no significant differences in deformity severity, estimated intraoperative blood loss, perioperative haemoglobin concentrations, or early postoperative complications. Although these findings are reassuring, they should be interpreted cautiously because of the very small number of HIV-positive patients. Nevertheless, the results support the contemporary view that well-controlled HIV infection should not be regarded as a contraindication to elective spinal deformity correction. Surgical decision-making should instead be based on comprehensive multidisciplinary assessment, optimisation of modifiable risk factors, and objective evaluation of immune function, rather than HIV serostatus alone. Larger prospective multicentre studies are required to confirm these findings and to define the long-term influence of HIV on spinal deformity surgery outcomes.

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