Centralisation of low-volume high complexity orthopaedic surgery: Hub-and-spoke models in the National Health Service

Neal Rupani, Vanessa J Chow, Jonathan L Rees and Steve Drew

Neal Rupani has just completed his Shoulder and Elbow Fellowship at University Hospital of Coventry and Warwickshire NHS Trust. He completed his specialist training within the Health Education Thames Valley Deanery, and will soon be commencing a consultant position with a special interest in Shoulder and Elbow Surgery.

Vanessa Jane Chow is an aspiring orthopaedic surgeon and graduate of St George's University. She has completed her foundation years in the Thames Valley Deanery and is currently pursuing an MSc in Advanced Surgical Practice.

A 2015 national review by Getting It Right First Time (GIRFT) identified unwarranted variation in patient care delivery and outcomes within orthopaedic surgery and recommended the hub and spoke model for low-volume high complexity surgery within the National Health Service (NHS)[1]. It is argued that the hub-and-spoke model would optimise operational efficiency, resource allocation and patient outcomes amidst national economic constraints and an ever-aging population.

Originating within the aviation and transportation industry, the hub and spoke model streamlines and centralises resource-intensive and infrequently performed procedures into a few specialist centres (hubs) whilst maintaining access to routine common surgery in community-based hospitals (spokes)[2]. Hubs are usually larger tertiary care hospitals or specialised centres equipped with multidisciplinary teams, advanced diagnostic and treatment capabilities, making them ideally suited for managing low-volume high complexity cases. Conversely, spokes are smaller hospitals that deliver high-volume low-complexity procedures and also serve as satellites to hubs in referring complex cases and supporting pre-operative investigation and post-operative care. This ensures comprehensive and coordinated patient care throughout the network or region. >>

Jonathan Rees is Professor of Orthopaedic Surgery and Musculoskeletal Science, Botnar Institute Director and Head of Department (NDORMS) at the University of Oxford. He is an NIHR Senior Investigator and Past President of the British Elbow and Shoulder Society (BESS).

Steve Drew is a Consultant Shoulder and Elbow Surgeon at University Hospitals Coventry and Warwickshire and the current President of the British Elbow and Shoulder Society (BESS).

Volume-outcome relationship

The rationale for centralising low-volume high complexity surgeries in higher volume hubs is primarily grounded in the evidence supporting a positive volume-outcome relationship, i.e. higher surgical volumes drive improved patient outcomes[3-5]. It is theorised that performing procedures more frequently improves technical proficiency, which leads to better outcomes[6].

This association has predominantly been demonstrated in high-volume lower limb surgery, such as total knee replacements (TKRs) and total hip replacements (THRs), where higher centre or surgeon volumes are associated with reduced rates of surgical site infection[7], revision[4,8,9], post-operative dislocation[5] and mortality[4,8-12]. For revision lower limb replacement surgery, lower mortality rates and improved lengths of stay were found in high-volume centres[13]. Higher-volume centres in total ankle replacement (TAR) have also shown fewer complications, shorter hospital stays, and reduced costs[14].

This relationship has been studied less in upper limb joint replacement. For total elbow replacement (TER), higher volume centres have achieved improved implant survival[15] and lower revision risks with registry data suggesting a 1.5 times risk reduction[16,17]. Similarly, for shoulder replacements, increased surgical volumes results in lower revision rates[3,18], fewer adverse events, shorter hospital stays and shorter operating times[18,19]. Recent peer-reviewed research indicates a career annual surgeon average of 10.4 primary shoulder replacement procedures results in lower revision rates[18].

However, the isolated use of a volume-outcome relationship has been criticised for:

- **Selective referral.** Better outcomes naturally attract more referrals and therefore drive higher surgical volumes, as opposed to the other way round[6].
- **Variable definitions.** There is variability in methodologies, data types and a lack of standardisation in how volume thresholds are calculated for different procedures.
- **Configurations.** High-volume centres may be made up of many low-volume surgeons, creating a fallacy for the gains in technical proficiency hypothesis.
- **Confounders.** Available evidence fails to consider individual hospital variables such as clinical guidelines, use of multi-disciplinary teams, surgeon expertise based on training, and variable case mixes[10,20].

A context-specific understanding of the volume-outcome relationship is desirable but challenging to achieve.

Current practice for joint replacement

Low-volume high complexity surgery was common in 2015, with 58.2% of revision TKRs and 45.9% of revision THRs performed by surgeons with an annual volume of five or fewer[1]. Despite this, data from the 2023 UK National Joint Registry report demonstrates the shift to a hub and spoke model to reduce the distribution of low-volume high complexity surgery has gained minimal traction[21], and is discussed below.

Hip and Knee Replacement. Both primary THRs and primary TKRs are considered high-volume procedures and conducted across most orthopaedic units with the annual number of replacements performed nearing 100,000 each. The numbers drop for revision replacements with 6,258 revision THRs and 5,464 revision TKRs performed in 2022, of which 1,196 and 889 were re-revision replacements respectively. The British Orthopaedic Association (BOA) and British Association for Surgery of the Knee (BASK) have recommended that complex or re-revisions TKRs are undertaken at hubs, with primary revisions being suitable in spokes which perform medium to high volume revisions[22]. Revision knee networks have been set up and piloted. Re-assessment of the new volume distribution and outcomes would help assess the clinical and healthcare cost impact of this change.

Shoulder Replacement. While primary shoulder replacements take place at lower volumes compared to THR and TKR, the numbers continue to increase. In 2022, 6,780 replacements were performed with a median surgeon volume of 10 across 370 hospitals. Although primary shoulder replacement is not considered a low volume procedure, it is worth noting that primary reverse total shoulder replacement (RTSR) is now a common treatment for proximal humeral fractures and over 25% of trauma RTSRs were performed by surgeons performing six or fewer annually. Revision shoulder replacement is a lower volume procedure with only 662 cases performed in 2022. Discussions are now taking place between NHSE, GIRFT and the British Elbow and Shoulder Society (BESS) on the topic of revision networks for revision shoulder replacement surgery.

Ankle Replacement. TARs performed have increased in total and per unit over the last decade but remain a low-volume high complexity procedure with 880 primary replacements performed in 161 units in 2022. Currently a third of TARs are performed by surgeons performing six or less annually and only seven units perform over 20 per year. GIRFT and British Orthopaedic Foot and Ankle Society (BOFAS) expect surgeon involvement in at least six TARs annually, along with the consideration of clinician passports and dual operating to support regional services and bolster surgeon experience[23].

Stakeholders	Advantages	Disadvantages
Patient	• Access to centralised hubs with concentrated expertise and coordinated multidisciplinary care which enhances outcomes for complex conditions[2]. • Routine care managed locally at spokes reduces travel for less complex needs, enhancing accessibility.	• Increased travel distances to specialised hubs can be inconvenient, expensive and lead to a lack of compliance and exacerbating healthcare inequities[34]. • Transfer delay, particularly in emergencies, leading to worse outcomes. • Potential delays in treatment due to inappropriate referrals to hubs.
Surgeon	• Surgeons at high-volume hubs benefit from frequent exposure to complex procedures enhancing surgical outcomes. • Hubs provide robust opportunities for continuous professional development, including structured mentorship and specialised training programs, essential for maintaining high standards[30].	• Surgeons at spoke centres may experience professional stagnation and diminished skill development due to limited opportunities to perform complex surgeries, leading to decreased job satisfaction and reduced morale. • Resistance from surgeons reluctant to give up 'hard-won' skills and experience at spoke centres, especially those with proven high-quality outcomes despite low procedural volumes[20]. • Potential loss of high-quality training opportunities and training surgeons if complex cases are entirely centralised at hubs, affecting skill diversity and development. • Unsupported staff managing outpatient care of complex patients.
Provider	• Centralisation in high-volume hubs promotes economies of scale thereby reducing operational costs and avoiding resource duplication. • Streamlined care pathways in hubs allow for efficient management of high-complexity cases. • Higher case volumes increase the ease of audit and research, particularly for infrequently performed procedures. • Shared regional governance meetings can allow good ideas and practice to be transmitted.	• Reimbursement models favouring high-volume, low-complexity procedures may undermine the financial viability of hubs, particularly for managing resource-intensive complex surgeries that are not appropriately compensated. • Increased patient volumes at hubs can strain bed capacity, operating theatres capacity , administrative workload and parking capacity, all potentially leading to longer wait times. • Ambiguity in defining specialised or complex surgery and arbitrary thresholds for minimum surgical volumes lead to inconsistencies in care delivery[10,20]. • Ineffective communication and coordination between hubs and spokes, due to underutilisation of digital tools and regional governance meetings, can fragment care delivery. • Diluted responsibility and accountability can hinder integrated care delivery.

Table 1: Advantages and disadvantages of the hub-and-spoke model from the perspectives of patients, surgeons, and healthcare providers.

Elbow Replacement. Only 281 TERs were performed in 2022, making it the lowest volume large-joint replacement and the major orthopaedic focus for introducing the hub and spoke model. GIRFT and BESS produced recommendations in 2017 for best practice and the provision of TERs, and strongly advocated for 1-2 regional hubs to be nominated to undertake this surgery[24]. Adoption of these recommendations and shifting to centralisation has been variable and limited. 99 surgeons across 92 units currently perform only 281 primary TERs (median number per consultant = 3, median number per unit = 2). The proportion of TERs being performed by high-volume (greater than 12) surgeons has increased but the proportion of surgeons performing four or less TERs has remained unchanged. Much of the delay in any full transition to elbow hub and spoke networks relates to NHS funding changes and adequate tariff for complex revision work. This funding has been approved in 2024 and the full transition to elbow replacement networks is now expected.

Other applications of the hub-and-spoke model

The perceived advantages and disadvantages of the hub and spoke model can be seen in Table 1. The benefits can be seen in real life examples, as centralisation in trauma and orthopaedics is not new or unique to joint replacement surgery. Nationally, high-severity trauma has been centralised to major trauma centres (MTCs). Since then, quality-of-care indicators and the rate of 'good recovery' outcomes have improved[25,26]. Patient volumes at MTCs also increased by 200%. Sarcoma services are also nationally centralised, with improved survival rates and disease-free intervals from this model being seen both within the UK and internationally[27-29].

More recently, a region centralised treatment for complex congenital talipes equinovarus[30], where primary correction rates were similar across both hub and spokes. Hub-treated patients required significantly fewer casts applications, had fewer complications, and were able to correct complications referred from spoke sites.

Examples have also highlighted key challenges to be considered prior to implementation. Delays in care arising from prolonged transfer times has been one of those key concerns. Definitive treatment for peri-prosthetic fractures was delayed by seven days when centralised[31]. Outside of orthopaedics, patients suffering from acute ischaemic stroke were unable to get thrombectomy treatment owing to this[32]. Robust communication and clear transfer protocols are essential to ensure effective patient management and minimise delays. Another key challenge was ensuring careful network planning and 'outreach work' to provide specialist support to spoke sites[33]. These examples illustrate the value and difficulties surrounding the hub and spoke model.

Summary

The hub-and-spoke model presents a recommended framework for enhancing orthopaedic care for low-volume procedures by centralising expertise, increasing operational efficiency and improving patient outcomes. However, challenges such as ensuring equitable and easy access for patients, along with ensuring engagement from the surgical community, NHS Trusts and commissioners need to be carefully considered. While the centralisation of low-volume, high complexity procedures is a persuasive argument some of the examples discussed highlight that any changes in the provision of services based on guidelines alone seem to be ineffective until coupled with new NHS network funding models. It is the opinion of the authors that until such funding models are in place, including levelling up of any disparity in tariffs paid to trusts for some of these resource-intensive procedures, then effective hub and spoke changes for low-volume procedures will not take place. There also remains scope for further monitoring and high-quality research of the clinical and cost effectiveness of these models. ■

References

References can be found online at www.boa.ac.uk/publications/JTO.