# Variations in the use of cemented implants for hip fracture repair in Nova Scotia, Canada

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**Background:** Opinions differ on the use of a cemented versus uncemented implant for repair of femoral neck fractures. The purpose of this study was to compare variation in the use of cemented implants for patients with hip fracture in Nova Scotia, Canada.

**Methods:** The study population was all patients who underwent primary emergency hip fracture arthroplasty in Nova Scotia between 2010/11 and 2019/20. We calculated 3 aggregate measures of variation across all hospitals: the extremal quotient (EQ) (ratio of the highest to the lowest rate of variation), the weighted coefficient of variation (WCV) (standard deviation divided by mean) and the systematic component of variation (SCV) (the between-surgeon variation, excluding the random component). Bootstrapped 95% confidence intervals (CIs) were computed.

**Results:** Our study population included 3787 patients with hip fracture who underwent arthroplasty at 5 hospitals, of whom 2219 (58.6%, 95% CI 57.1%–60.2%) received cemented implants. The age- and sex-adjusted proportion of cemented cases ranged from 36.6% (95% CI 33.6%–40.0%) to 71.1% (95% CI 68.4%–73.8%). The highest EQ value was 30.3 (95% CI 0.0–80.0). The WCV ranged from 32.6 (95% CI 28.5–36.7) to 77.3 (95% CI 68.3–86.3). The SCV indicated very high between-surgeon variation at all hospitals. The WCV and SCV resulted in the same rankings for all hospitals, indicating consistency between the 2 measures.

**Conclusion:** We found considerable variation across surgeons in the use of cemented implants for patients with hip fracture in Nova Scotia. Guidelines could help build consensus on this practice among surgeons.

**Contexte :** Les opinions diffèrent au sujet de l'utilisation de prothèses cimentées ou non cimentées pour la réparation des fractures du col du fémur. Le but de cette étude était de comparer les variations quant à l'utilisation des prothèses cimentées pour la réparation des fractures de la hanche en Nouvelle-Écosse, au Canada.

**Méthodes :** La population de l'étude comprenait l'ensemble de la patientèle ayant subi une arthroplastie primaire d'urgence pour fracture de la hanche en Nouvelle-Écosse, entre 2010/2011 et 2019/2020. Nous avons calculé les mesures de variation agrégées pour tous les hôpitaux : quotient extrémal (QE) (rapport entre les taux de variation les plus élevés et les plus bas), coefficient de variation pondéré (CVP) (écart-type divisé par la moyenne) et composante systématique de la variation (CSV) (variation d'un spécialiste à l'autre, à l'exclusion de la composante aléatoire). Des intervalles de confiance (IC) de 95 % avec rééchantillonage (bootstrap) ont été calculés.

**Résultats :** La population de notre étude se composait de 3787 cas de fracture de la hanche soumis à une arthroplastie dans 5 hôpitaux et 2219 d'entre eux (58,6 %, IC de 95 % 57,1 %–60,2 %) ont reçu des implants cimentés. La proportion ajustée selon l'âge et le sexe des cas cimentés a varié de 36,6 % (IC de 95 % 33,6 %–40,0 %) à 71,1 % (IC de 95 % 68,4 %–73,8 %). La valeur du QE le plus élevé à été de 30,3 (IC de 95 % 0,0–80,0). Le CVP a varié de 32,6 (IC de 95 % 28,5–36,7) à 77,3 (IC de 95 % 68,3–86,3). La CSV a indiqué une forte variation entre les spécialistes de tous les hôpitaux. Le CVP et la CSV ont donné lieu aux mêmes classifications pour tous les hôpitaux, indiquant une constance entre les 2 mesures.

**Conclusion :** Nous avons observé une variation considérable entre les spécialistes quant à l'utilisation des implants cimentés pour la réparation des fractures de la hanche en Nouvelle-Écosse. La préparation d'une ligne directrice pourrait contribuer à rendre cette pratique plus consensuelle.

Femoral neck fractures are a priority area for policy-makers in Canada owing, in part, to the prevalence of the injury, with associated high mortality rates.[1–3] Arthroplasty is a common method of treatment; however, there is a lack of consensus among clinicians with regard to the use of cemented versus uncemented implants. Consistently, evidence indicates better outcomes with the use of cement,[4,5] yet wide variations in cementing rates continue.[6] As Troelsen and colleagues[7] have suggested, there is an "uncemented paradox," meaning that, despite overwhelming evidence showing poorer outcomes, uncemented fixation rates remain high in some countries. Those authors concluded that surgical cultures have developed within each country, which helps explain differences in rates. This conclusion, however, implies there is homogeneity in the use of cemented or cementless fixation within countries. In Nova Scotia, Canada, a recent study showed higher mortality among patients who underwent hip arthroplasty with a cementless implant than among those who received a cemented implant,[8] yet, to our knowledge, the extent of variation in the use of cement in the province has not been studied.

In Canada, individual surgeons make decisions with respect to the choice of implant. It is plausible that differences in cementing rates may occur across surgeons even at the hospital level. The literature comparing surgical rates across geographic regions suggests this is due mainly to medical opinion and physician preferences.[9–12] Uncertainty leads to differing opinions on the best treatment.[10,13] Variation patterns are often specific to procedures and occur across international boundaries. It has been shown, for example, that variations are high for tonsillectomy and hemorrhoidectomy, but low for appendectomy across countries. This pattern of variation owing to uncertainty is seen with procedures with both low and high rates.[11] Although the use of cement in arthroplasty is known to differ significantly across countries,[7] variation within countries is poorly characterized.

Rate variation studies are valuable tools in understanding quality care. Often, however, policy-makers and providers do not believe variations exist within their own jurisdictions.[14] A first step toward affecting change is measurement. Methodologies that have been developed to study variation in surgical procedures across geographic areas can be applied to compare variation in cementing rates within hospitals. Using these methods to examine variability in cement use in Canada may help identify means to improve outcomes in hip fracture management.

The purpose of this study was to compare the variation in the use of cemented implants for hip fracture across hospitals in Nova Scotia with the use of aggregate measures of variation.

## Methods

The study population was all patients who underwent primary arthroplasty for femoral neck fracture included in the Canadian Institute for Health Information Discharge Abstract Database in Nova Scotia from 2010/11 to 2019/20. To maintain adequate sample sizes across all hospitals, we analyzed hemiarthroplasty and total arthroplasty procedures together. Patients were distributed across surgeons according to the emergency on-call schedule, meaning cases were less subject to selection bias compared to elective joint replacement procedures. We identified patients with hip fracture as those admitted with a diagnosis of fracture of the femoral neck (*International Classification of Diseases, 10th revision* code S72). We used Canadian Classification of Health Interventions codings to select patients who underwent arthroplasty and categorize their cases into cemented and uncemented.

We computed rates of cemented implants, adjusting for age and sex differences, by surgeon for each of the 5 study hospitals. The adjustment factor assumes the same patient age and sex distribution for all surgeons — namely, that for all of Nova Scotia — to account for any rate differences that may occur owing to patient characteristics. Since there are no established volume classifications for cementing, we divided rates into tertiles across the entire province and used the maximum value for each tertile as the threshold for low, medium and high cementers, respectively.

We calculated 3 measures of variation for each facility. The extremal quotient (EQ) is the ratio of the highest to the lowest rate. A measure less sensitive to outliers is the population-weighted coefficient of variation (WCV), defined as the standard deviation divided by the mean.[15] Finally, we calculated the systematic component of variation (SCV), which nets out the random component.[11] In the context of the present study, the random component is the within-surgeon variation (i.e., patient level), meaning the SCV isolates the variation between surgeons. To be included, a surgeon must have performed more than 10 operations over 3 years or more. We categorized SCV thresholds of 10.0 and 5.4 as very high and high variation, respectively.[10] Each of the 3 measures gives an aggregate measure of variation for each hospital that can be compared directly. We estimated 95% confidence intervals (CIs) by generating 1000 bootstrap samples for each hospital and calculating the standard deviation of means to obtain the standard errors.[16]

Analyses were carried out with SAS 9.4 (SAS Institute). Research ethics approval was granted by the Nova Scotia Health Authority Research Ethics Board.

## Results

There were 3984 hip fracture cases identified in the study period. Of these, 197 were excluded because the surgeon

performed fewer than 10 cases over 3 years or more, leaving 3787 patients; of the 3787, 2219 (58.6%, 95% CI 57.1%–60.2%) had a cemented implant. There were 7, 5, 7, 17 and 8 surgeons included at hospitals 1, 2, 3, 4 and 5, respectively. The proportion of implants that were cemented at the 5 hospitals ranged from 36.6% (95% CI 33.6%–40.0%) to 71.1% (95% CI 68.4%–73.8%) (Figure 1). At 1 hospital, surgeons were more than twice as likely to use cement as surgeons at the hospital with the lowest rate of cemented implants. Figure 2 illustrates variation in rates of cement use by surgeon at each hospital. At hospitals 1 and 2, there were distinct groupings apparent whereby individual surgeon rates were in or near the highest grouping, whereas the remaining surgeons had rates that were less than half that of the lowest cementing threshold. All 5 hospitals had rates in each of the low, medium and high groupings. Over time, rates for the entire province increased, from 45.7% in 2010/11 to 70.2% in 2019/20; there was an increase of 12.4 percentage points (57.8% to 70.2%) in the period 2015/16 to 2019/20 (Figure 3).

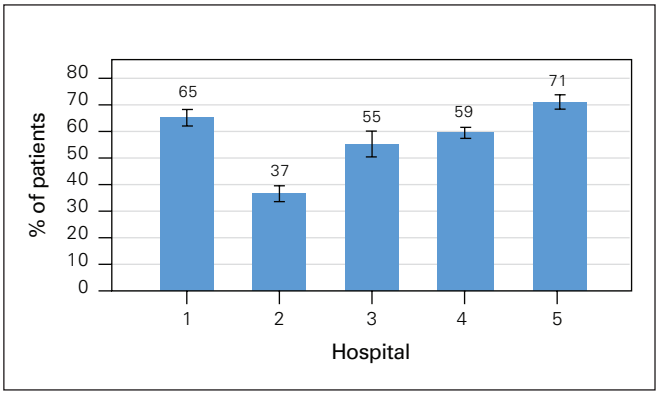


**Fig. 1.** Age- and sex-adjusted proportion of patients who underwent hip fracture arthroplasty and received cemented implants, by hospital, 2010/11 to 2019/20. Error bars represent 95% confidence intervals.

Measures of variation are given in Table 1. The largest EQ was observed for hospital 4, where the cementing rate of the surgeon with the highest rate (98.1%) was 30 times that of the surgeon with the lowest rate (3.2%). The smallest EQ, 3.4, was observed for hospital 5. One surgeon at hospital 3 did not use cement in any cases, so the EQ was undefined. The highest WCV, 77.3, occurred at hospital 2, and the lowest, 32.6, occurred at hospital 5. The lower-bound WCV 95% CI at hospital 2 was higher than the upper-bound 95% CI for any of the other hospitals. Finally, the SCV ranged from 7.7 to 53.8, with 4 hospitals categorized as having very high between-surgeon variation. Furthermore, the lower-bound 95% CI for each of these hospitals was within the "very high" category. The fifth hospital had an SCV point estimate classified as high variation.

There was consistency between the WCV and SCV, as the 2 measures resulted in the same rankings for all hospitals (Table 2). Hospital 2 had the highest variation and hospital 5 the lowest for the 2 measures. It is noteworthy that hospital 5 had the highest cementing rate (Figure 1) and the lowest levels of variation, as determined with all 3 measures. Conversely, hospital 2 had the lowest cementing rate and smallest number of surgeons yet the highest variation overall.

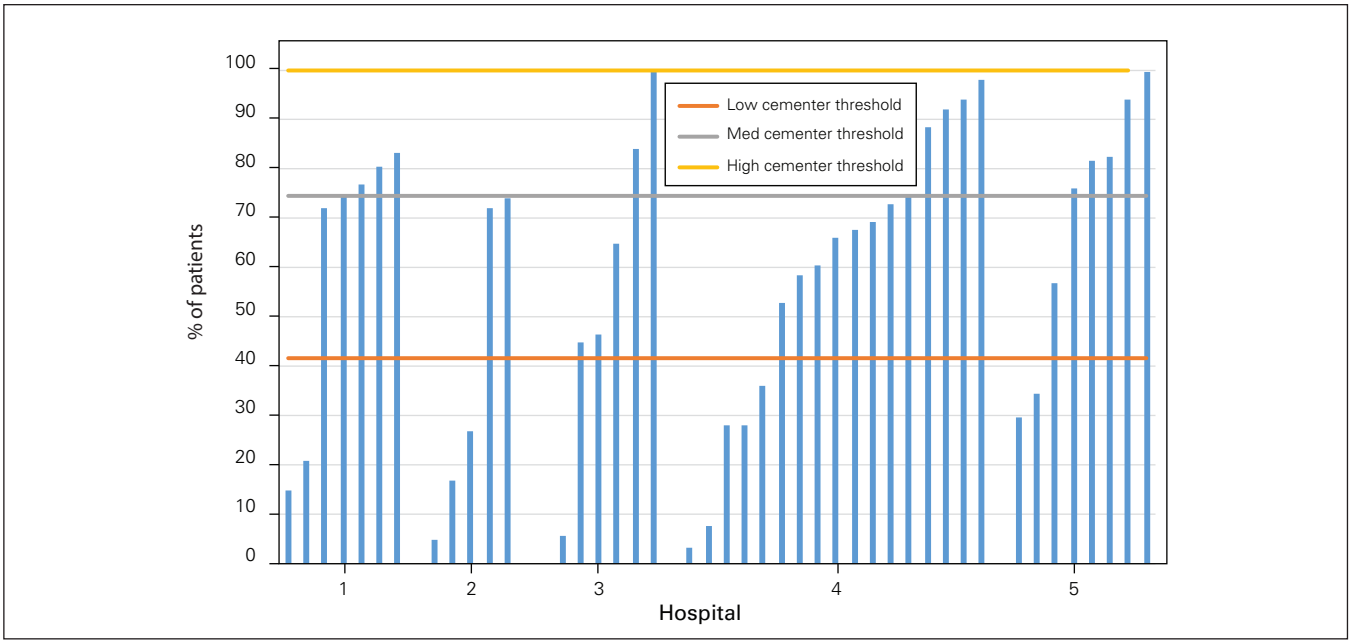


**Fig. 2.** Age- and sex-adjusted proportion of patients who received cemented implants at each hospital, by surgeon. One surgeon at hospital 3 had a cementing rate of 0%.

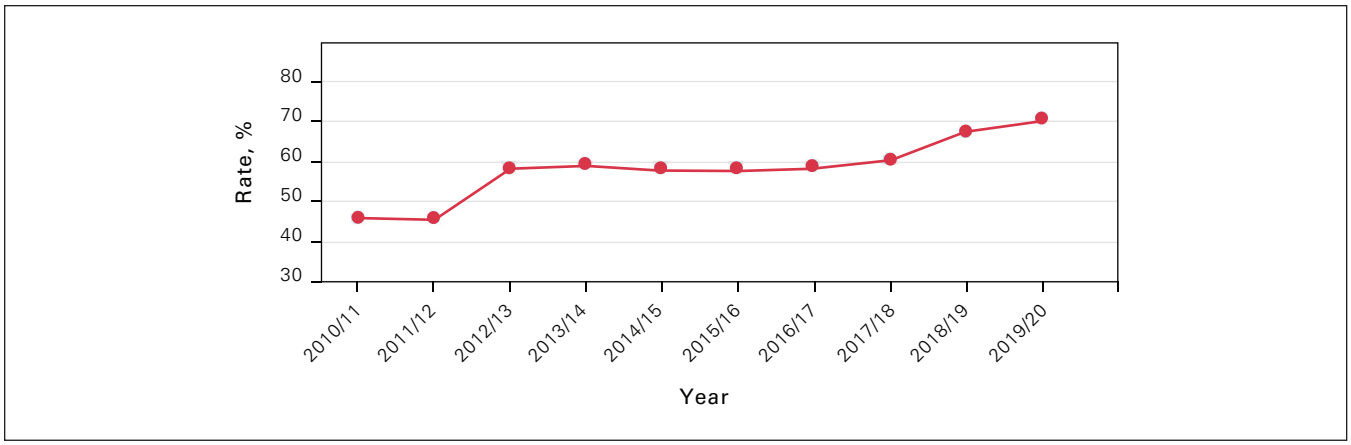


**Fig. 3.** Cementing rates for Nova Scotia, 2010/11 to 2019/20.

**Table 1. Between-surgeon variation in use of cemented implants in primary arthroplasty for femoral neck fracture by hospital, Nova Scotia, 2010/11 to 2019/20**

| Hospital | No. of surgeons | Extremal quotient (95% CI) | Weighted coefficient of variation (95% CI) | Systematic component of variation (95% CI) |
|---|---|---|---|---|
| 1 | 7 | 5.5 (0.0–18.0)* | 39.2 (34.1–44.2) | 18.8 (12.0–25.6) |
| 2 | 5 | 14.7 (0.0–34.2)* | 77.3 (68.3–86.3) | 53.8 (41.5–66.1) |
| 3 | 7 | ND | 55.0 (48.0–62.0) | 39.5 (14.2–64.8) |
| 4 | 17 | 30.3 (0.0–80.0)* | 51.6 (48.1–55.1) | 20.1 (16.5–23.7) |
| 5 | 8 | 3.4 (0.97–5.8) | 32.6 (28.5–36.7) | 7.7 (3.8–11.6) |

CI = confidence interval; ND = not defined.
*The lower bound was negative and was replaced with 0.

**Table 2. Hospital ranking by variation measure**

| | Measure; hospital | | |
|---|---|---|---|
| Variation | Extremal quotient* | Weighted coefficient of variation | Systematic component of variation |
| Highest variation | 4 | 2 | 2 |
| | 2 | 3 | 3 |
| | 1 | 4 | 4 |
| | 5 | 1 | 1 |
| Lowest variation | — | 5 | 5 |

*Not defined for hospital 3.

## Discussion

Despite a preponderance of evidence suggesting that the use of cemented implants results in better patient outcomes,[17–21] including in Nova Scotia,[8] we found considerable within-hospital variation in the rate of cemented implants used for patients with hip fracture in Nova Scotia. The clinical reasoning for these improved outcomes is a more firmly fit implant within the femur[21] and less difficulty inserting screws around the implant that improve the fixation strength,[22] resulting in fewer refractures.[20,23] This has led to less reported pain and improved function.[18,21,24] Translating evidence to clinical care is challenging,[25] particularly in this era of rapidly changing information. This "volume overload" makes it overwhelming to surgeons wishing to implement change in their surgical practice.[26] Professional organizations can synthesize information and develop guidelines, which have been shown to be effective in reducing variation in surgical procedures,[27,28] especially when clinicians are directly involved in their development.[29,30] Guidelines on the use of cement for hip fracture repair are in place in many countries, including the United Kingdom, Australia, Norway and the United States — each recommending its use — yet in Canada, there are no such guidelines. Variation in practice patterns drive initial discussions on implementing guidelines; therefore, an understanding of the extent of variation can encourage such dialogue.[28] The Canadian Orthopaedic Association is committed to providing continuing education for surgeons and the highest standard of care.[31] Given indications of substantial variation, the evidence on outcomes and standards set by other national orthopedic associations, there is an opportunity for national and specialty organizations such as the Canadian Orthopaedic Association to provide clarity and leadership by generating guidelines on the use of cement for hip fracture repair.

International comparisons of cementing rates have shown variation across continents[32,33] and countries.[6,7] Our results indicate that the division extends down to individual surgeons. Although there may be a "country

culture,"[7] in Nova Scotia, circumstances have not fostered a consensus, even within hospitals. The use of cement requires experience[5,7] and coordination within the operating team.[34] If cementless fixation is favoured, there is a risk over time that surgical team members will lose the skills required to effectively use cement for hip arthroplasty.

Our results indicate that cementing rates increased across the entire province over the study period. It is plausible that, as more evidence emerges regarding improved outcomes for cemented implants, surgeons are increasingly choosing this treatment for patients. A 2010 study by Parker and colleagues[4] is considered a seminal paper on the improved outcomes with the use of cement for patients with hip fracture.[35] This paper may have had an influence on the observed increase in cementing rates in 2011/12 and subsequent years in our study.

Understanding why surgeons choose uncemented implants is an important factor in working toward a consensus. The authors of an influential study suggested that bone cement implantation syndrome, which is characterized mainly by hypoxia or hypotension or both,[36] may be of concern to surgeons.[37–39] A UK guideline has since suggested that older patients and those with cardiopulmonary disease may be at risk for bone cement implantation syndrome;[34] however, this does not appear to explain our results. Pre-existing cardiac conditions and increasing age show no association with the probability of a patient's receiving a cemented implant (unpublished data, 2021). As well, the risk of bone cement implantation syndrome as a factor in the decision to use cement was not mentioned in a recent international survey of orthopedic surgeons.[40]

We are not suggesting that all patients with hip fracture receive a cemented implant. The international survey indicated that 82% of surgeons use both techniques.[40] In the present study, only 1 surgeon used cement exclusively, and 1 never used it. If there were agreement on which patients are at high risk for complications after the use of cement, however, rates would consolidate to within a small range, and there would be little variation around that aggregate rate, whether low or high.

### *Limitations*

The study population was that of Nova Scotia only; therefore, the results may not be generalizable to other provinces. Given that the data sources used for this study lacked clinical information, there may be other associated factors that influence the choice of fixation. Surgeon characteristics, including age and training, likely influence the decision to use cement, but this information was unavailable owing to confidentiality restrictions. Finally, there may have been differences across hospitals in the proportion of patients with hip fracture who underwent arthroplasty, which may have affected cementing rates.

## Conclusion

Treatment options for surgical patients at high risk such as those with a hip fracture should be rigorously debated in order to provide optimal care. Overwhelming evidence indicates superior outcomes with the use of cemented implants, yet high variation in cement use in Nova Scotia suggests a consensus has not been reached among surgeons. Future direction for this work includes using additional data in Nova Scotia to control for other factors, including surgeon characteristics. An examination of variation across other provinces would reveal whether results similar to ours occur nationwide.

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**Competing interests:** Glen Richardson reports consulting fees from Stryker and DePuy Synthes, payment and honoraria for speakers bureaus and lectures from Stryker, and support for attending meetings and travel from Stryker. He sits on the Hip Innovation Technology Data Safety Monitoring Board and the Canadian Orthopaedic Association Board of Directors, and is chair of the Canadian Orthopaedic Association CPD Committee. He holds stock or stock options in Stryker. Michael Dunbar received the Queen Elizabeth II Health Sciences Centre Foundation Endowed Chair in Arthroplasty Outcomes, which pays Lynn Lethbridge's salary. He reports royalties/licences from Stryker, consulting fees from Stryker and DePuy Synthes, and payment and honoraria for presentations and educational events from Stryker. No other competing interests were declared.

**Contributors:** M. Dunbar designed the study. L. Lethbridge acquired the data, which L. Lethbridge and G. Richardson analyzed. L. Lethbridge wrote the manuscript, which G. Richardson and M. Dunbar critically revised. All authors gave final approval of the article to be published.



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