Osteoporosis International (2019) 30:2241–2248
https://doi.org/10.1007/s00198-019-05089-1

ORIGINAL ARTICLE

Laboratory evaluation of secondary causes of bone loss in Veterans with spinal cord injury and disorders

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Received: 29 April 2019 / Accepted: 10 July 2019 / Published online: 13 August 2019

Abstract

Summary An electronic health record (eHR) review of Veterans with a spinal cord injury and disorder (SCI/D) was conducted to understand the extent to which Veterans Affairs (VA) providers pursue workups for secondary causes of osteoporosis in this population. Laboratory tests for secondary causes were ordered in only one-third of Veterans, with secondary causes identified in two-thirds of those tested, most frequently, hypogonadism and hypovitaminosis D.

Purpose To identify workups for secondary causes of osteoporosis in SCI/D and the extent to which subspecialty consultations are sought.

Methods A total of 3018 prescriptions for an osteoporosis medication (bisphosphonate, calcitonin, denosumab, raloxifene, teriparatide) among 2675 Veterans were identified in fiscal years 2005–2015 from VA administrative databases. Approximately 10% of these prescriptions were selected for eHR review.

Results eHR records of 187 Veterans with a SCI/D who had received pharmacological treatment for osteoporosis were reviewed. Workups for secondary causes of osteoporosis were performed in 31.5% of Veterans ($n = 59$) with approximately 64.4% of those tested ($n = 38$) having at least one abnormality. Hypogonadism (52.0% of those tested) and hypovitaminosis D (50.0% of those tested) were the most common secondary causes of osteoporosis identified in this population. Approximately 10% of primary care and SCI providers consulted subspecialists for further evaluation and treatment of osteoporosis. Endocrinologists more frequently performed a workup for secondary causes of osteoporosis compared to other provider specialties.

Conclusions Screening for secondary causes of osteoporosis, particularly for hypogonadism and hypovitaminosis D, should be considered in patients with a SCI/D.

Keywords DXA · Medications · Osteoporosis · SCI/D

Introduction

Osteoporotic fractures in patients with spinal cord injuries and disorders (SCI/D) are associated with substantial morbidity [1] and excess mortality [2], yet currently available treatments to prevent fracture have limited, if any, efficacy [3]. Potentially, identification and treatment of secondary causes of osteoporosis may be one strategy to positively impact on fracture reduction in this population. One prior expert report from Canada stressed the importance of screening for

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secondary causes of osteoporosis in persons with a SCI as secondary causes can be mistaken for or worsen the effect of typical sublesional osteoporosis in this population [4]. In this series, approximately 30% of patients with a chronic SCI had a secondary cause of osteoporosis identified [4].

To our knowledge, no previous studies have evaluated the extent to which secondary laboratory causes of osteoporosis are performed in Veterans with both traumatic and nontraumatic SCI in the USA. Moreover, differences among provider specialties relative to the extent of evaluation for secondary causes of osteoporosis in patients with a SCI/D have not previously been explored.

Therefore, the primary objective of this study was to identify the extent, type, and results of screening laboratory tests for workups for secondary causes of osteoporosis in Veterans with a SCI/D. Secondary objectives were to evaluate the specialty of providers ordering this testing and the extent to which subspecialty consultations were sought in the management of osteoporosis in patients with a SCI/D.

Methods

A total of 64,811 Veterans with an SCI/D were identified between fiscal years (FY) 2005–2015 using the Veteran's Health Administration's (VHA) Allocation Resource Center (ARC) file which uses ICD codes and treatment in either an SCI bed section and/or SCI outpatient clinic to define a patient as SCI/D [5] (see also Appendix 1). Health care utilization, demographics, and pharmacy data were obtained from VHA Enterprise Corporate Data Warehouse (CDW).

To obtain SCI-specific data, we utilized the SCD (Spinal Cord Dysfunction) Registry, which included Veterans with SCI/D who received care at a VHA medical facility. This administrative database was maintained by individual VHA SCI/D Centers to track the population Veterans with SCI/D followed by each center. The SCIDO (Spinal Cord Injury and Disorders Outcomes) Registry continued the SCD Registry purpose and was administratively maintained; however, SCIDO also allowed clinical patient outcome data to be included. The SCD and SCIDO historical data are archived in the VHA Enterprise virtual environment. These historical datasets include information about etiology, date of onset, level of injury, completeness of injury, and the Veteran's health care [5].

Selection of Veterans for eHR review

Figure 1 illustrates the strategy for selecting Veterans and filled prescriptions for electronic health record (eHR) review. Individuals with a traumatic injury were identified with ICD-9 codes of 806.2–806.7, 952.1–952.4, 344.1, and 907.2; nontraumatic spinal cord disorders included ICD-9 codes 806, 806.0, 806.1, 806.8, 806.9, 952, 952.0, 952.9, 952.9, 344, and 344.0. A total of 10,784 Veterans were excluded due to a comorbid diagnosis of Paget's disease (ICD-9 code 731.0) or malignant neoplasm (ICD-9 codes 140-208) since bisphosphonates; denosumab and calcitonin are also indicated for use in these conditions. Another 27,605 Veterans were excluded, as they had no VA health care utilization during the study period due to either death prior to FY2005 or nonuse of VA services.

Among the remaining 26,332 Veterans, the pharmacy data files were queried to identify filled prescriptions for Food and Drug Administration (FDA)-approved pharmacological agents for osteoporosis including bisphosphonates (alendronate, ibandronate, risedronate, and zoledronic acid), calcitonin, denosumab, raloxifene, or teriparatide from FY2005–FY2015. Both the first and last dates for each filled prescription were captured when available.

We identified 2675 Veterans with a traumatic or nontraumatic SCI/D diagnosis who had any of these medications (Fig. 1); these patients had a total of 3018 filled prescriptions. A random 10% sample ($n = 301$) of these filled prescriptions were selected for detailed manual eHR review. However, since bisphosphonates are the most common drug class used to treat osteoporosis in Veterans with SCI/D [6], medications other than bisphosphonates were rarely pulled from this random sample. Accordingly, other medications for osteoporosis (calcitonin, denosumab, raloxifene, and teriparatide) were purposely sought and their records reviewed. If a Veteran had more than one medication in the study period, all of them were reviewed. A total of 267 Veterans with 330 filled prescriptions underwent an eHR review to describe the workups of secondary causes of osteoporosis performed when initiating an osteoporosis medication.

We used ICD-9 code 733.xx to observe the frequency of a diagnosis of osteoporosis in our initial sample of 2675 Veterans from administrative data and in our final sample of 267 Veterans selected for eHR review. Among our initial sample, 1729 Veterans (64.6%) had a diagnosis of osteoporosis. Among our final sample, 135 Veterans (72.1%) had a diagnosis of osteoporosis.

A detailed, manual eHR review was performed by two physician extractors using a data abstraction tool developed and agrees upon by all authors (see Appendix 2). The Compensation and Pension Records Interchange (CAPRI) network was used to access

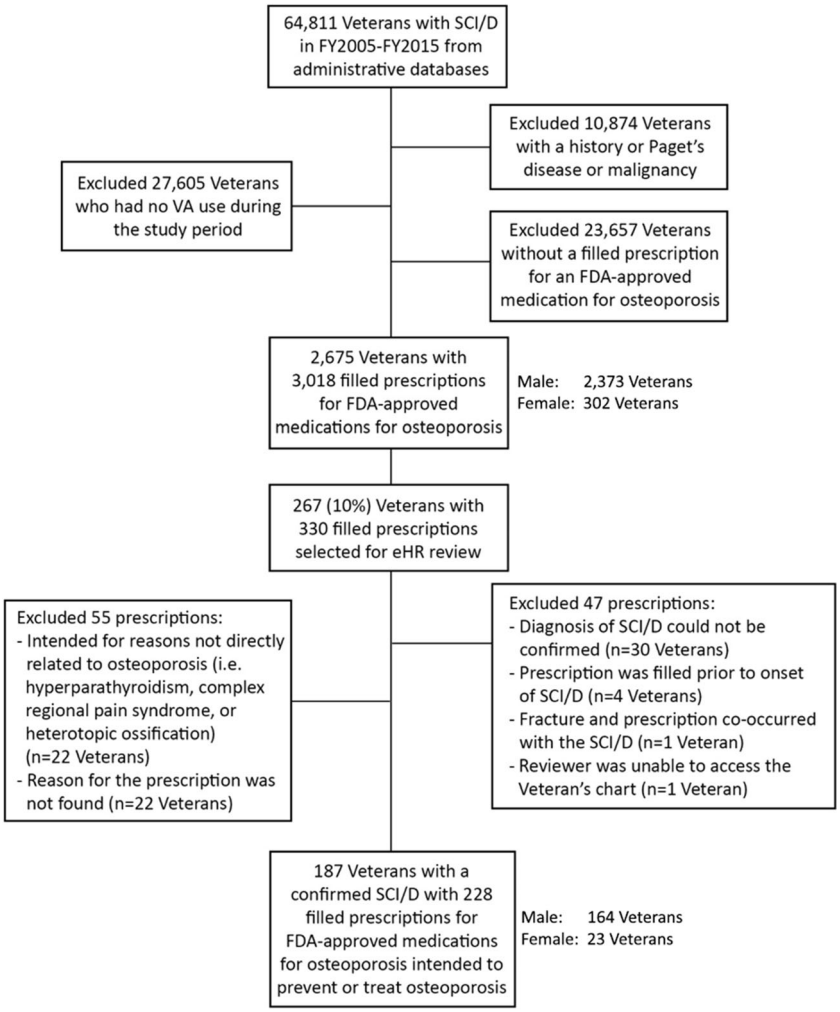

Fig. 1 Selection of cohort of Veterans for eHR review

Veterans' health records from VA health administration facilities across the USA and its territories.

Clinical notes from SCI providers, primary care providers, and subspecialists were reviewed 90 days before and 90 days following the first date of the filled prescription during the study period. If it appeared that the medication had been prescribed prior to the study period, review of clinical notes extended further back to the first note documenting the start of the medication. The search bar was used to aid in identifying relevant notes using the following key words: osteopenia, osteoporosis, DXA, DEXA, bisphosphonate, alendronate, fosamax, risedronate, actonel, ibandronate, calcitonin, miacalcin, denosumab, prolia, raloxifene, teriparatide, and forteo.

Laboratory evaluation for secondary causes of osteoporosis was considered present if the prescribing provider or the referred subspecialist had documented intent to obtain relevant studies and if numerical values and/or interpretations for these studies were available in either clinical notes or cumulative laboratory test results. Normal laboratory data performed 90 days prior to the start of the pharmacological agent which appeared relevant (for example, an ionized calcium level) but was not documented were included only if the prescribing provider had documented intent to obtain other studies or specific review of these studies in the context of the evaluation for osteoporosis. Serological testing sought included the following: serum protein electrophoresis (SPEP), 25-hydroxyvitamin D, intact parathyroid hormone (PTH), serum and ionized calcium, free and total testosterone, thyroid stimulating hormone (TSH), 24-h urine calcium, and 24-h urine cortisol. The American Association Clinical Endocrinologists' standard of 30 ng/mL as the lower limit of normal for 25-hydroxyvitamin D was used to determine vitamin D status [7].

Veterans who had secondary laboratory screening were additionally reviewed to determine whether they had a dual X-

ray absorptiometry (DXA) scan. DXA scans were reviewed up to 1 year before and 1 year after the prescription start date. If a patient had multiple DXA scans or multiple prescriptions, only the first DXA scan impressions were recorded.

Subspecialist referrals for further workup and management of osteoporosis placed by the prescribing provider were searched for up to 1 year after the initiation of the pharmacologic agent.

Institutional Review Board (IRB) approval for this study was obtained from the Charlie Norwood VA in Augusta, GA and the Hines VA in Chicago, IL.

Results

A detailed, manual eHR review was conducted for a total of 330 (10.9%) filled prescriptions among 267 (10.0%) Veterans. Seventy-five filled prescriptions among 58 Veterans were excluded because the diagnosis of SCI/D could not be confirmed ($n = 30$ Veterans); the reason for the prescription was not found ($n = 22$); the prescription was started prior to SCI/D ($n = 4$); a fracture and prescription occurred at the same time as the SCI/D ($n = 1$); or the eHR was unable to be accessed ($n = 1$). Another 27 prescriptions among 22 Veterans were excluded as the prescriptions were intended for reasons not directly related to osteoporosis (such as hyperparathyroidism, complex regional pain syndrome or heterotopic ossification). Following all exclusions, a study sample of 187 Veterans with a SCI/D had filled prescriptions for an FDA-approved osteoporosis medication used to prevent or treat osteoporosis during this time period and was included in these analyses.

At baseline, the study sample had a mean age of 52.4 years (standard deviation 14.2 years). The majority of these Veterans were male ($n = 164$, 87.7%) and were predominantly of White ($n = 145$, 83.3%) race. Blacks comprised 12.1% of the study sample ($n = 21$) and other races 4.6% ($n = 8$). Etiologies of SCI/D were mostly traumatic ($n = 132$, 70.6%), followed by nontraumatic ($n = 49$, 26.2%) and unknown ($n = 6$, 3.2%) etiologies. Nontraumatic injuries were largely inflammatory/autoimmune ($n = 29$), followed by infectious ($n = 9$), degenerative ($n = 3$), vascular ($n = 3$), neoplastic/cystic ($n = 2$), compression fracture-related ($n = 2$), and metabolic ($n = 1$) causes. The study sample contained relatively even distributions of extents of injury (incomplete, $n = 69$ (36.9%); complete, $n = 59$ (31.6%); unknown, $n = 59$ (31.6%)) as well as levels of injury (tetraplegia, $n = 74$ (39.6%); paraplegia $n = 75$, (40.1%); unknown, $n = 38$ (20.3%)).

Laboratory testing for workup of secondary causes of osteoporosis was ordered in 31.5% of Veterans ($n = 59$). Among those tested, 38 Veterans (64.4% of Veterans with a workup) had at least one abnormal laboratory test. When differentiated by sex category, laboratory testing was ordered in 31.7% male Veterans ($n = 52$), and among those tested, 34 Veterans (65.3% of male Veterans with a workup) had at least one abnormal laboratory test. In comparison, laboratory testing was ordered in 20.4% female Veterans ($n = 7$), and among those tested, 4 Veterans (57.1% of female Veterans with a workup) had at least one abnormal laboratory test.

Figure 2 illustrates the total number of workups and ratio of normal to abnormal laboratory tests. The most frequent laboratory test ordered was a serum calcium (corrected for hypoalbuminemia and/or ionized) ($n = 55$), followed by 25-hydroxyvitamin D ($n = 50$), TSH ($n = 39$), intact PTH ($n = 28$), and testosterone (free and/or total) ($n = 25$). Other less commonly performed tests include 24-h urine calcium ($n = 13$), SPEP ($n = 11$), and 24-h urine cortisol ($n = 5$). The most common abnormal laboratory test results were hypogonadism (free testosterone < 241 ng/dL and/or total testosterone < 2.8 pg/mL) ($n = 13$, 52.0% of those tested) and hypovitaminosis D (25-hydroxyvitamin D < 30 ng/mL) ($n = 25$, 50.0% of those tested).

Among Veterans with secondary laboratory screening, 79.7% of Veterans ($n = 47$) had a DXA scan. Among

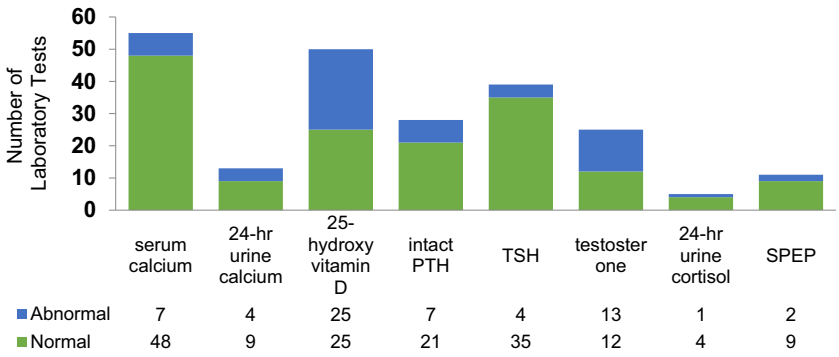

Fig. 2 Workup for secondary causes of osteoporosis ($N = 59$ Veterans)

Veterans with a DXA scan, these scans most commonly demonstrated osteoporosis ($n = 36$) followed by osteopenia ($n = 8$). There were 3 Veterans who had normal bone mineral density.

Endocrinologists more frequently performed a workup for secondary causes of osteoporosis ($n = 16$, 88.9% of all endocrinologists) compared to primary care providers ($n = 19$, 23.4% of all primary care providers) and SCI providers ($n = 7$, 11.5% of all SCI providers). There were three rheumatologists who had initiated an osteoporosis medication; none of them performed a workup for secondary causes of osteoporosis.

Consultations to specialists for further management of osteoporosis were few in the study sample ($n = 19$, 10.2% of all Veterans). There were twelve consultations to endocrinology, five to rheumatology, and two to other subspecialists (PharmD-led metabolic bone clinic, hematology-oncology). Almost 83.8% ($n = 67$) of all primary care providers who initiated a pharmacological treatment for osteoporosis did not consult a subspecialty for management of osteoporosis; likewise, 96.7% ($n = 59$) of SCI providers did not involve subspecialists in the care of Veterans with osteoporosis.

Discussion

The major finding of this study is that only approximately one-third of Veterans with a SCI/D who are prescribed pharmacological therapies for osteoporosis have a laboratory workup for secondary causes of osteoporosis performed. However, the majority of those tested have a secondary cause identified, most commonly, hypogonadism and hypovitaminosis D. Subspecialty consultations for osteoporosis are seldom sought; however, subspecialists, specifically endocrinologists, are much more likely to order secondary workups for osteoporosis than were primary care or SCI providers.

That only one-third of Veterans with a SCI/D had an evaluation for secondary causes of osteoporosis is consistent with reports in the general population without a SCI/D. A retrospective cohort of women referred to a Woman's Health Center at the Cleveland Clinic for a DXA scan revealed that among those with Z-scores of ≤ -1.5 (age 27–48 years), only 27.8% of primary care physicians pursued a workup for secondary causes despite recommendations to do so by the International Society for Clinical Densitometry (ISCD) [8]. It has been postulated that the reasons workups for secondary causes of osteoporosis are infrequently performed in the general population include the following: (1) Providers may not be proficient in evaluating secondary causes [8]; (2) primary care providers may be overburdened by more immediate health-threatening diseases [9]; and (3) cost constraints in the primary care setting may discourage further workup from being pursued [9]. These reasons may also be operative for providers of patients with SCI/D; however, this population has additional unique challenges that may underlie why these workups are rarely performed. Sublesional bone loss osteoporosis may be perceived by providers as perhaps the only, if not the most potent, mechanism for BMD loss in SCI/D; thus, providers may question the clinical meaningfulness of obtaining a secondary evaluation [10]. Not only is there little to no evidence that pharmacological treatment of osteoporosis is efficacious in SCI/D, but there are also no reports that treating secondary causes of osteoporosis in persons with a SCI/D reduces fracture rates or improves bone mass [11].

The majority of patients tested in this series had a secondary laboratory cause of osteoporosis identified. This is more than previously reported in one study, in which approximately 18% of men and premenopausal women with a chronic SCI and low BMD had serological evidence of parathyroid disease, thyroid disease, vitamin D deficiency, hypogonadism, hypercalciuria, or chronic liver disease [4]. Our study differs from this [4] in that we included both traumatic and nontraumatic causes of SCI as well as acute and chronic durations of disease, and most importantly, identified workups on the basis of having had a filled prescription for a pharmacological agent for osteoporosis and not on the basis of BMD testing.

In our series, hypogonadism and hypovitaminosis D were the most common laboratory abnormalities identified. In support of these findings, a high prevalence of hypogonadism and hypovitaminosis D has also been previously reported in persons with a SCI/D especially among men with a chronic SCI. A cross-sectional analysis of 58 young men with SCI (ages 18–45 years) found that hypogonadism was more prevalent in SCI compared to age-matched non-SCI controls; furthermore, the risk of developing hypogonadism in SCI increased with more extensive injury [12]. In addition, a serological evaluation of 49 men with chronic SCI undergoing a rehabilitation program found an independent linear association between low 25-hydroxyvitamin D and low testosterone levels; this was associated with poor independent functioning and poorer weekly leisure time physical activity [13]. Our data suggests that in persons with a SCI/D, workup for secondary causes of osteoporosis should include, at a minimum, serological screening for hypogonadism in men and for hypovitaminosis D in men and women.

Similar to the general population, in persons with a SCI/D, osteoporosis is often managed in the primary care setting [9]. Subspecialty consultation is seldom sought; however, when evaluated by an endocrinologist, workup for secondary causes occurred more frequently in comparison to primary care and SCI providers. In accord with these findings, one report suggested that over 95% of bone specialists (including endocrinologists and rheumatologists) pursued a secondary evaluation in the setting of an abnormal DXA [8]. In contrast with this report [8], rheumatologists in our analyses did not order these secondary laboratory workups; however, there were few rheumatologists consulted.

This study has a number of important strengths. A detailed review of the eHR was undertaken in this study to examine provider intent and cross-reference this with laboratory data; thus, both clinical notes and actual laboratory values were reviewed when available. To our knowledge, this is the first report of the extent to which evaluation for a number of secondary causes of osteoporosis is performed in clinical practice in the SCI/D population in the USA.

However, there are several limitations that deserve consideration. To start, common to all retrospective studies using administrative data, a selection bias may have occurred due to the manner with which diagnoses are coded. Furthermore, the administrative database only records information on filled prescriptions; therefore, if a VA provider had prescribed a medication, but the patient did not fill it, this medication would not be captured by the database. In addition, approximately 12% of Veterans receive care outside the VA system [14]. Thus, if a non-VA provider had prescribed a medication for osteoporosis or had performed a secondary workup for osteoporosis, these cases would have not been included in our analyses. With respect to the limitations of our eHR review, only a 10% sample of the entire cohort of Veterans was selected for review and they were predominantly men. We only included laboratory testing if the provider indicated this was ordered; thus, if a provider had considered prior laboratory testing in their decision-making without explicit documentation, this would not have been considered in our evaluation and underreporting would be an issue. Secondary causes of osteoporosis may differ with respect to time since injury, particularly disorders of calcium homeostasis [15], and duration of injury was not considered in our analyses. We only examined secondary workups for osteoporosis in those who were prescribed pharmacological therapies for osteoporosis, not in the population as a whole. Thus, we did not determine whether workups were being done at other time points not resulting in a prescription for a medication for osteoporosis, such as an initial evaluation for an acute injury or as part of an annual exam. Finally, we did not examine other secondary causes of osteoporosis not obtained by serological data such as alcohol and smoking use and medications.

Conclusion

In clinical practice, only a minority of patients with a SCI/D who are prescribed pharmacological therapies for osteoporosis have a workup for a secondary cause of osteoporosis. However, secondary causes of osteoporosis occur in two-thirds of those tested. While secondary causes of osteoporosis in the general non-SCI/D population are associated with lower BMD and increased fracture rates [16], this relationship in SCI/D has yet to be studied. Inconsistent screening for secondary causes of osteoporosis in SCI/D may represent a missed opportunity to assess, and potentially reduce, fracture risk in this population. Thus, serological testing for secondary causes of osteoporosis, in particular, hypogonadism and hypovitaminosis D prior to provision of pharmacological therapies for osteoporosis should be considered in patients with a SCI/D.

Funding This work was funded by the Department of Defense (DOD) Grant #SC150092.

Compliance with ethical standards

Institutional Review Board (IRB) approval for this study was obtained from the Charlie Norwood VA in Augusta, GA and the Hines VA in Chicago, IL.

Conflicts of interest None.

Disclaimer The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the US Government.

Appendix 1. Data documentation on how to identify SCI/D patients using VA centralized databases

There are three components involved in identifying SCI/D patients using VA administrative databases including the Allocation Resource Center (ARC) files. The first component is the use of ICD diagnostic codes. The second component involves the selection of a particular VA bed section—22 is the bed section for spinal cord injury, and the third component is the selection of a clinic stop of 210 in the outpatient clinic file. Stop 210 is the SCI clinic stop code.

The ARC diagnosis inclusion codes for SCI/D are as follows:

ICD9	Description	ICD9	Description
Paraplegia new		Tetra new	
806.20	T1-T6 FX-CL/CORD INJ NOS	806.00	C1-C4 FX/CORD INJ NOS
806.21	T1-T6 FX-CL/COM CORD LES	806.01	C1-C4 FX-CL/COM CORD LES
806.22	T1-T6 FX-CL/ANT CORD SYN	806.02	C1-C4 FX-CL/ANT CORD SYN
806.23	T1-T6 FX-CL/CEN CORD SYN	806.03	C1-C4 FX-CL/CEN CORD SYN
806.24	T7-T12 FX-CL/CORD INJ NEC	806.04	C1-C4 FX-CL/CORD INJ NEC
806.25	T7-T12 FX-CL/CORD INJ NOS	806.05	C5-C7 FX-CL/CORD INJ NOS
806.26	T7-T12 FX-CL/COM CORD LES	806.06	C5-C7 FX-CL/COM CORD LES
806.27	T7-T12 FX/CL?ANT CORD SYN	806.07	C5-C7 FX-CL/ANT CORD SYN
806.28	T7-T12 FX/CL/CEN CORD SYN	806.08	C5-C7 FX-CL/CEN CORD SYN
806.29	T7-T12 FX-CL/CORD INJ NEC	806.09	C5-C7 FX-CL/CORD INJ NEC
806.3	OPN DORSAL FX W CORD INJ	806.1	OPEN CERV FX W CORD INJ
806.30	T1-T6 FX-OP/CORD INJ NOS	806.10	C1-C4 FX-OP/CORD INJ NOS
806.31	T1-T6 FX0OPO/COM CORD LES	806.11	C1-C4 FX-OP/COM CORD LES
806.32	T1-T6 FX-OP/ANT CORD SYN	806.12	C1-C4 FX-OP/ANT CORD SYN
806.33	T1-T6 FX-OP/CEN CORD SYN	806.13	C1-C4 FX-OP/CEN CORD SYN
806.34	T1-T6 FX-OP/CORD INJ NEC	806.14	C1-C4 FX-OP/CORD INJ NEC
806.35	T7-T12 FX-OP/CORD INJ NOS	806.15	C5-C7 FX-OP/CORD INJ NOS
806.36	T7-T12 FX-OP/COM CORD LES	806.16	C5-C7 FX-OP/COM CORD LES
806.37	T7-T12 FX-OP/ANT CORD SYN	806.17	C5-C7 FX-OP/ANT CORD SYN
806.38	T7-T12 FX-OP/CEN CORD SYN	806.18	C5-C7 FX-OP/CEN CORD SYN
806.39	T7-T12 FX-OP/CORD INJ NED	806.19	C5-C7 FX-OP/CORD INJ NEC
806.4	CL LUMBAR FX W CORD INJ	806.8	VERT FX NOS-CL W CORD INJ
806.5	OPEN LUMBAR FX W CORD INJ	806.9	VERT FX NOS-OP W CORD INJ
806.6	FX SACRUM-CL W CORD INJ	952.0	CERVIAL SPINAL CORD INJ
806.60	FX SACREUM-CL/CORD INJ NOS	952.00	C1-C4 SPIN CORD INJ NOS
806.61	FX SACR-CL/CAUDA EQU LES	952.01	COMPLETE LES CORD/C1-C4
806.62	FX SACR-CL/CAUDA INJ NEC	952.02	ANTERIOR CORD SYND/C1-C4
806.69	FX SACRUM-CL/CORD INJ NEC	952.03	CENTRAL CORD SYND/C1-C4
806.7	FX SACRUM-OPN W CORD INJ	952.04	C1-C4 SPIN CORD INJ NEC
806.70	FX SACRUM-OP/CORD INJ NOS	952.05	C5-C7 SPIN CORD INJ NOS
806.71	FA SACRUM-OP/CAUD EDQ LES	952.06	COMPLETE LES CORD/C5-C7
806.72	FX SACR-OP/CAUDA INJ NEC	952.07	ANTERIOR CORD SYND/C5-C7
806.79	FX SACRUM-OP/CORD INJ NEC	952.08	CENTRAL CORD SYND/C5-C7
952.10	T1-T6 SPIN CORD INJ NOS	952.09	C5-C7 SPIN CORD INJ NEC
952.11	COMPLETE LES CORD/T1-T6	952.8	SPIN CORD INJ-MULT SITE
952.12	ANTERIOR CORD SYND/T1-T6	952.9	SPINAL CORD INJURY NOS
952.13	CENTRAL CORD SYND/T1-T6	TETRA OLD	
952.14	T1-T6 SPIN CORD INJ NEC	344.0	Quadriplegia NOS
952.15	T7-T12 SPIN CORD INJ NOS	344.00	Quadriplegia unspecified
952.16	COMPLETE LES CORD/T7-T12	344.01	Quadriplegia C1-C4 complete
952.17	ANTERIOR CORD SYN/T7-T12	344.02	Quadriplegia C1-C4 incomplete
952.18	CENTRAL CORD SYN/T7-T12	344.03	Quadriplegia C5-C7 complete
952.19	T7-T12 SPIN CORD INJ NEC	344.04	Quadriplegia C5-C7 incomplete
952.2	LUMBAR SPINAL CORD INJ	344.09	Other quadriplegia
952.3	SACRAL SPINAL CORD INJ		
952.4	CAUDA EQUINA INJURY		
Paraplegia OLD			
344.1	Paraplegia NOS		
907.2	Late eff SPINAL CORD INJ		

Appendix 2

Data collected from eHR review of Veterans with filled prescriptions for FDA-approved medications for osteoporosis

Filled prescription	- Bisphosphonate - Calcitonin - Denosumab - Raloxifene - Teriparatide
Sex of Veteran	
Etiology of SCI/D	- Traumatic - Nontraumatic - Unknown
Reasons for initiating medication for osteoporosis	- Fracture occurred - Radiograph performed for a suspected fracture that was negative for fracture but revealed osteopenia/osteoporosis - Radiograph performed for reasons other than a suspected fracture with an incidental finding of osteopenia/osteoporosis - DXA with osteopenia (with skeletal site of lowest bone density) - DXA with osteoporosis (with skeletal site of lowest bone density) - Fall risk - Prior history of osteoporosis - Chronic steroid use - Heterotopic ossification - Hyperparathyroidism - Complex regional pain syndrome - Other reason
Specialty of prescribing provider	- Primary care provider - SCI provider - Endocrinology - Rheumatology - Other specialty
Status of medication for osteoporosis	- Still on medication - Death, unrelated to medication - Death, related to medication - Discontinued medication
Reasons for discontinuing medication for osteoporosis	- "Drug holiday" - Osteonecrosis of the jaw - Atypical femoral fracture - Other reason

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