Health Services Research

Utilization and Expenditures of Vertebral Augmentation Continue to Decline: An Analysis in Fee-For-Service (FFS) Recipients from 2009 to 2018

Laxmaiah Manchikanti, MD[1], Sri Harsha Vardhan Senapathi, MD[2], James M. Milburn, MD[3], Allan L. Brook, MD[4], Bramha Prasad Vangala, MBBS[5], Vidyasagar Pampati, MSc[1], Mahendra R. Sanapati, MD[1], and Joshua A. Hirsch, MD[6]

From: [1]Pain Management Centers of America, Paducah, KY & Evansville, IN; [2]Guthrie Robert Packer Hospital, Sayre, PA; [3]Ochsner Medical Center, Department of Radiology, New Orleans, LA, [4]Albert Einstein College of Medicine and Montefiore Medical Center, Bronx, NY; [5]Apollo Hospitals, Secunderabad, India; [6]Massachusetts General Hospital and Harvard Medical School, Boston, MA

Address Correspondence:
Laxmaiah Manchikanti, M.D.
67 Lakeview Drive
Paducah, Kentucky 42001
E-mail: drlm@thepainmd.com

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Background: Despite the high prevalence of vertebral compression fractures (VCFs) associated with refractory pain, deformity, or progressive neurological symptoms, minimally invasive vertebral augmentation procedures, including vertebroplasty and kyphoplasty, have been declining in their relative utilization, along with expenditures.

Objectives: This investigation was undertaken to assess utilization and expenditures for vertebral augmentation procedures, including vertebroplasty and kyphoplasty, in the fee-for-service (FFS) Medicare population from 2009 to 2018.

Study Design: The present study was designed to assess utilization and expenditures in all settings, for all providers in the FFS Medicare population from 2009 to 2018 in the United States. In this manuscript:
- A patient was described as receiving vertebral augmentation over the course of the year.
- An episode was considered as one treatment per region per day utilizing primary codes only.
- Services or procedures were considered to be procedures including multiple levels.

A standard 5% national sample of the Centers for Medicare and Medicaid Services (CMS) physician outpatient billing claims data for those enrolled in the FFS Medicare program from 2009 to 2018 was utilized. All the expenditures were presented with allowed costs and adjusted for inflation to 2018 US dollars.

Results: In 2009, there were 76,860 episodes of vertebral augmentation with a rate of 168 per 100,000 Medicare population, which declined to 58,760, or 99 per 100,000 population for a total decline of 41%, or an annual rate of decline of 5.7% per 100,000 Medicare population. Vertebroplasty interventions declined more dramatically than kyphoplasty from 2009. Total episodes of vertebroplasty were 27,380 with an annual rate of 60 per 100,000 Medicare population, decreasing to 9,240, or 16 per 100,000 Medicare population, a 66% decline in episodes and a 74% decline in overall rate with an annual decline of 11.4% and 13.9%. In contrast, kyphoplasty interventions were 49,480, for a rate per 100,000 population of 108 in 2009 compared to 49,520 in 2018 with a rate of 83, for a decrease of 23% and 2.9% annual decrease.

Evaluation of expenditures showed a net decrease of $30,102,809, or 8%, from $378,758,311 in 2009 to $348,655,502 in 2018. However, inflation-adjusted expenditures decreased overall by 21% and 3% annually from $443,147,324 in 2009 to $345,655,502 in 2018. In addition, inflation-adjusted total expenditures per 100,000 Medicare population decreased from $967,549 to $584,992, for an overall decrease of 40%, or an annual decrease of 5%. Per patient expenditures decreased 2% overall with 0% decrease per year.

Limitations: Vertebral augmentation procedures were assessed only in the FFS Medicare service population. This excluded over 30% of the Medicare population, which is enrolled in Medicare Advantage plans.

Conclusions: This study shows a significant decline in relative utilization patterns of vertebroplasty and kyphoplasty procedures, along with reductions in overall expenditures. The inflation-adjusted total expenditures of kyphoplasty and vertebroplasty decreased 21% with an annual decline of 3%. The inflation-adjusted expenditures per 100,000 of Medicare population decreased 40% overall and 5% per year. In addition, vertebroplasty has seen substantial declines in utilization and expenditure patterns compared to kyphoplasty procedures, which showed trends of decline.

Key words: Osteoporosis, osteoporotic compression fracture, vertebroplasty, kyphoplasty, vertebral augmentation, expenditures, inflation-adjusted, utilization

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In the United States, as the population ages, the incidence of osteoporotic fractures, such as vertebral compression fractures (VCFs) continues to increase (1-4). VCFs can be associated with refractory pain to conservative management and drug therapy with deformity or progressive neurological symptoms (5-8). Minimally invasive vertebral augmentation procedures, including kyphoplasty and vertebroplasty, have been used for osteoporotic or pathologic fractures, including metastatic fractures associated with persistent pain and disability nonresponsive to conservative management (1-4,9-15). However, significant controversy has been present since the publication of 2 randomized controlled trials (RCTs) in the *New England Journal of Medicine*, each of which demonstrated no beneficial effect of vertebroplasty over sham procedure (16,17). In addition, other factors influencing utilization patterns could include the enactment of the Affordable Care Act (ACA) in March 2010, 7 months following these publications (18-20). Multiple publications have provided conflicting information in reference to the effectiveness and appropriateness criteria of augmentation procedures (1-15,21-55). During this time, the focus also shifted from vertebroplasty to kyphoplasty with significant reductions in vertebroplasty procedures (3,36-38,51). Since 2009 multiple systematic reviews, guidelines, clinical trials, cost effectiveness, and quality of life studies have been published demonstrating the efficacy of vertebral augmentation, which encompasses all percutaneous treatment of vertebral fractures, whether just cement is injected, or a device such as a balloon is used (1-15,21-50). Guidelines from the Department of Health and Human Services (HHS) on Best Practices in Pain Management prominently focused on interventions to reduce opioids and increase the quality of life (51,52). The opioid epidemic saw a spike in the number of deaths due to COVID-19 (53-62). Consequently, multiple measures have been developed to continue interventional pain management and provide appropriate care to chronic pain patients (63-66). Thus, COVID-19's pandemic and simultaneous revival of the opioid epidemic, in conjunction with reduced access, have caused significant declines in utilization patterns, as well as expenditures of many interventional procedures (53,54,63-66) compared to epidural interventions, facet joint interventions, and spinal cord stimulators (53,54,67-74).

There continues to be discrepancies in the presentation of utilization data as well as expenditures. We have undertaken this study to assess expenditures and utilization patterns of percutaneous vertebral augmentation procedures in the United States fee-for-service (FFS) Medicare population from 2009 to 2018.

Methods

This analysis of expenditures and utilization patterns in the FFS Medicare population was performed utilizing a retrospective cohort analysis with methodology as described by the Strengthening and Reporting of Observational Studies in Epidemiology (STROBE) (75). The data was obtained from the Centers for Medicare and Medicaid Services' (CMS) physician outpatient billing claims for those enrolled in the FFS Medicare program for 2009 through 2018, consisting of the standard 5% national sample (76). The sample data consisting of 5% from CMS has been reported to be unbiased and unpredictable to avoid divulging any patient characteristics. However, the data does allow tracking of patients over time and across databases. Institutional Review Board (IRB) approval was not required for this study.

Study Design

The estimation of expenditures for vertebral augmentation in FFS Medicare recipients was designed as a retrospective cohort study calculating the trends of expenditures and utilization patterns from 2009 to 2018 in the United States (76). In this analysis:

- A patient was considered as undergoing vertebral augmentation over the course of the year, irrespective of number of visits, episodes, or services.

- An episode was considered as one per region per day utilizing primary codes only.
- Services or procedures were considered to be all procedures, multiple levels including add-on codes.

Setting

The standard 5% national sample data was obtained from the CMS services physician outpatient billing claims for those enrolled in the FFS Medicare program from 2009 to 2018. Participants included all Medicare FFS recipients receiving vertebral augmentation. The current procedural terminology (CPT) codes included in this analysis are listed in Table 1.

Data Sources

CMS physician billing claims for those enrolled in the FFS Medicare program from 2009 to 2018 provided the appropriate data, facilitating the analysis.

Data Compilation

Data was compiled utilizing Microsoft 365 Access and Microsoft 365 Excel (Microsoft, Redmond, WA). We removed all vertebral augmentation services not allowed or approved with zero payments. One hundred percent data was obtained by multiplication by 20 to scale up from our 5% sample to the full FFS Medicare population. The data were calculated for overall services for each procedure, and the rate of services, based on utilization per 100,000 FFS Medicare beneficiaries. Expenditures were also calculated for physician and facility for vertebroplasty and kyphoplasty, which included allowable charges for physician and facility (ambulatory surgery center [ASC], hospital outpatient department [HOPD], office setting). All the expenditures were presented with allowed expenditures and were adjusted for inflation to 2018 US dollars. HOPD facility allowed charges were estimated based on National Average rates.

Variables

The analysis of trends of utilization and expenditures patterns of vertebral augmentation procedures incorporated multiple variables with analysis and expenditures for all procedures, utilization based on statewide and Medicare Administrative Contractors (MACs) and location of the service provided, either office-, ASC-, or HOPD-based.

Measures

Allowed services were assessed for each procedure. Rates were calculated based on Medicare beneficiaries for the corresponding year and are reported as procedures per 100,000 Medicare beneficiaries. Data was assessed for the total number of procedures performed, as well as the number of episodes for vertebral augmentation. An episode is considered as one per region, irrespective of number of procedures performed.

Table 1. *CPT codes utilized for vertebral augmentation procedures from 2009 to 2018.*

CPT code	Description
Codes until 2014	
22520	Percutaneous Vertebroplasty - Cervical/Thoracic
22521	Percutaneous Vertebroplasty - Lumbar/Sacral
22522	Percutaneous Vertebroplasty - Each additional cervicothoracic or lumbosacral
22523	Percutaneous Kyphoplasty - Cervical/Thoracic
22524	Percutaneous Kyphoplasty - Lumbar/Sacral
22525	Percutaneous Kyphoplasty - each additional cervicothoracic or lumbosacral
Codes from 2015 to 2018	
22510	Percutaneous Vertebroplasty - Cervical/Thoracic
22511	Percutaneous Vertebroplasty - Lumbar/Sacral
22512	Percutaneous Vertebroplasty - Each additional cervicothoracic or lumbosacral
22513	Percutaneous Kyphoplasty - Cervical/Thoracic
22514	Percutaneous Kyphoplasty - Lumbar/Sacral
22515	Percutaneous Kyphoplasty - Each additional cervicothoracic or lumbosacral

Bias

Data was purchased from the CMS by the American Society of Interventional Pain Physicians (ASIPP). The study was conducted with the internal resources of the primary author's practice without external funding. The expenditures were determined without eliciting any bias. Thus, based on the large size of the dataset derived from a government source, there was no information related to patients' individual identification.

Sample Size

The size of this retrospective cohort study is robust, providing real-world claims data on FFS Medicare patients undergoing vertebral augmentation for spinal pain from 2009 to 2018.

Results

Participants and Characteristics

In this analysis, the participants were from the Medicare database undergoing vertebral augmentation from 2009 to 2018.

Utilization Characteristics

Table 2 shows descriptive data with summary of the frequency of utilization of augmentation procedures in the Medicare population from 2009 to 2018. The data also shows that Medicare population increased from 45,801,000 to 59,600,000 in 2018 with an overall change of 30% and annual increase of 3%.

The number of patients undergoing vertebral augmentation decreased from 64,640 in 2009 to 52,000 in 2018, with an overall decrease of 20% and annual decrease of 2.4%. The total number of procedures decreased from 96,180 to 76,080, a 21% decrease and annual decrease of 2.6%, the rate per 100,000 population was 163 in 2009, which decreased to 99 with a 39% decline, with an annual decline of 5.3%. For vertebroplasty procedures, the total procedures decreased from

Table 2. *Summary of the frequency of utilization of vertebroplasty and kyphoplasty in the Medicare population from 2009 to 2018.*

Services	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Change	GM
Medicare (,000)	45,801	46,914	48,300	50,300	51,900	53,500	54,900	56,500	58,000	59,600	30%	3.0%
Vertebroplasty												
22510	12,600	12,360	9,060	7,660	7,260	5,980	4,860	5,100	5,100	4,560	-64%	-10.7%
22511	14,780	12,680	9,840	8,360	6,320	6,220	5,300	5,040	4,800	4,680	-68%	-12.0%
22512	6,180	5,860	4,120	4,020	3,160	3,000	3,060	2,560	3,540	2,640	-57%	-9.0%
Total Services	33,560	30,900	23,020	20,040	16,740	15,200	13,220	12,700	13,440	11,880	-65%	-10.9%
Rate	73	66	48	40	32	28	24	22	23	20	-73%	-13.5%
Episodes	27,380	25,040	18,900	16,020	13,580	12,200	10,160	10,140	9,900	9,240	-66%	-11.4%
Rate	60	53	39	32	26	23	19	18	17	16	-74%	-13.9%
Kyphoplasty												
22513	23,800	22,740	23,280	22,860	22,900	21,680	21,680	25,260	24,000	23,520	-1%	-0.1%
22514	25,680	24,220	24,400	27,000	26,120	26,500	24,760	27,180	26,520	26,000	1%	0.1%
22515	13,140	12,040	11,680	12,660	11,760	12,280	13,320	16,200	16,300	14,680	12%	1.2%
Total Services	62,620	59,000	59,360	62,520	60,780	60,460	59,760	68,640	66,820	64,200	3%	0.3%
Rate	137	126	123	124	117	113	109	121	115	108	-21%	-2.6%
Episodes	49,480	46,960	47,680	49,860	49,020	48,180	46,440	52,440	50,520	49,520	0%	0.0%
Rate	108	100	99	99	94	90	85	93	87	83	-23%	-2.9%
Vertebroplasty & Kyphoplasty combined												
Total Services	96,180	89,900	82,380	82,560	77,520	75,660	72,980	81,340	80,260	76,080	-21%	-2.6%
Rate	210	192	171	164	149	141	133	144	138	128	-39%	-5.4%
Episodes	76,860	72,000	66,580	65,880	62,600	60,380	56,600	62,580	60,420	58,760	-24%	-2.9%
Rate	168	153	138	131	121	113	103	111	104	99	-41%	-5.7%
Visits	74,600	68,920	63,860	63,260	59,980	58,120	56,920	60,180	61,000	59,200	-21%	-2.5%
Rate	163	147	132	126	116	109	104	107	105	99	-39%	-5.3%
Patients	64,640	59,360	55,100	55,600	52,460	51,260	49,880	51,400	52,680	52,000	-20%	-2.4%
Rate	141	127	114	111	101	96	91	91	91	87	-38%	-5.2%
Age												
>=65	73,440	68,600	63,080	62,380	58,920	57,100	53,980	58,600	56,920	55,560	-24%	-3.1%
Percentage	96%	95%	95%	95%	94%	95%	95%	94%	94%	95%	-1%	-0.1%
Rate	160	146	131	124	114	107	98	104	98	93	-42%	-5.8%
< 65	3,420	3,440	3,500	3,500	3,680	3,280	2,620	3,980	3,500	3,200	-6%	-0.7%
Rate	7	7	7	7	7	6	5	7	6	5	-28%	-3.6%

33,560 in 2009 to 11,880 in 2018 for a 65% decrease, with an annual decrease of 10.9%. The rate of Medicare population undergoing vertebroplasty decreased from 73 to 20 per 100,000 Medicare population, for a 73% decrease and an annual decrease of 13.5%. In contrast, the changes in kyphoplasty were significantly less dramatic. The total number of kyphoplasty episodes were 62,620 in 2009, increasing to 64,200 in 2018, with a 3% increase or 0.3% increase per year. However, the rate of Medicare recipients undergoing kyphoplasty declined from 137 in 2009 to 108, a 21% decrease overall, or a decrease of 2.6% per year. This table also shows that majority of the procedures were performed on those who were older than 65 years of age.

Figure 1 shows the rate of utilization of vertebroplasty and kyphoplasty procedures per 100,000 Medicare population from 2009 to 2018 in Medicare beneficiaries. Figure 2 shows annual change in utilization characteristics of kyphoplasty and vertebroplasty.

Table 3 shows the summary of the frequency of utilization of vertebroplasty and kyphoplasty procedures in the Medicare population. Combined data of vertebroplasty and kyphoplasty shows that 92% of 76,860 or 70,840 procedural episodes in 2009 were in hospital settings, which decreased to 79% of 58,760 to 46,540, with an overall utilization decrease of 34% and 4.6% per year. The remaining 8% were performed with one-third in ASC settings, and two-thirds in an office setting in 2009 with the ratio further changing to 15% in ASC settings, with office settings showing an increase of 157%, for an annual increase of 11.1%. In contrast, the episodes of vertebroplasty were 81% in hospital settings with 22,100 of 27,380 in 2009, decreasing to 8,700 constituting 94%, with a 61% decrease in utilization rate overall and 9.8% per year. Thus, over the years vertebroplasty procedures performed in ASC and office settings declined significantly. However, for kyphoplasty episodes, the data shows that 99% of the episodes were performed in HOPD settings in 2009 with 48,740 of 49,480, decreasing to 37,840 of 49,520, placing in reference to the proportion at 76% for an overall decline of 22% and annual decline of 2.8%. ASCs showed a 138% increase overall with 10.1% annual increase; however, with only 740 episodes in 2009, increasing to 1,760 in 2018. In contrast, for office settings they have been performed since 2012, with 2,960 of 49,860, increasing to 9,920 of 49,520, with significant increases of 235% from 2012 to 2018. Figure 3 shows vertebroplasty and kyphoplasty episodes by place of service for Medicare beneficiaries from 2009 to 2018.

Specialty Characteristics

Appendix Table 1 and Appendix Fig. 1 show

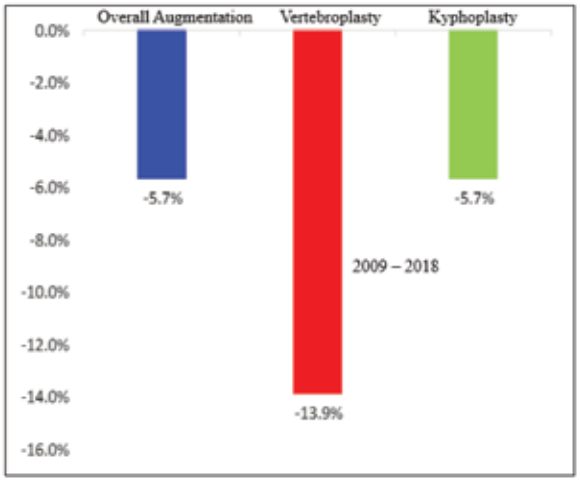

Fig. 2. *Annual change in relative utilization characteristics of kyphoplasty and vertebroplasty per 100,000 Medicare population.*

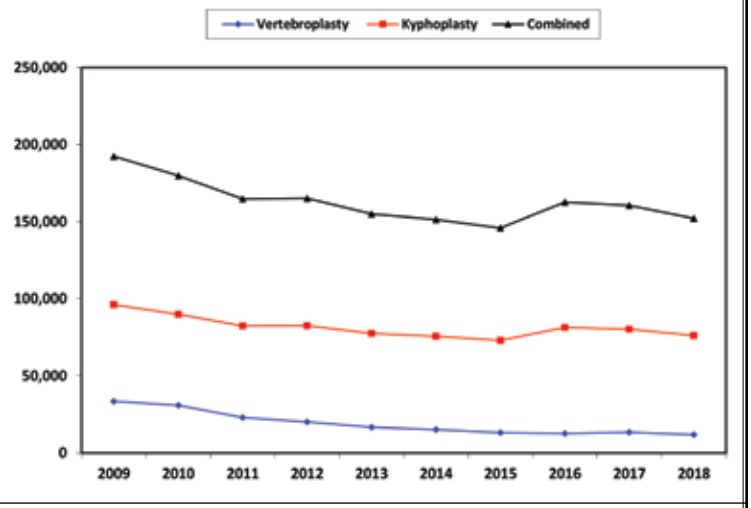

Fig. 1. *Rate of utilization of vertebroplasty and kyphoplasty procedural episodes per 100,000 Medicare population from 2009 to 2018 in Medicare beneficiaries.*

Table 3. *Summary of the frequency of utilization of vertebroplasty and kyphoplasty procedural episodes in the Medicare population by place of service from 2009 to 2018.*

	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Change	GM
Vertebroplasty												
HOPD*	22,100	20,420	15,760	14,360	12,600	11,480	9,540	9,380	9,040	8,700	-61%	-9.8%
%	81%	82%	83%	90%	93%	94%	94%	93%	91%	94%	17%	1.7%
Rate	48	44	33	29	24	21	17	17	16	15	-70%	-12.4%
ASC	1,300	1,000	480	360	300	220	220	340	200	220	-83%	-17.9%
Rate	3	2	1	1	1	0	0	1	0	0	-87%	-20.3%
Office	3,980	3,620	2,660	1,300	680	500	400	420	660	320	-92%	-24.4%
Rate	9	8	6	3	1	1	1	1	1	1	-94%	-26.6%
Total	27,380	25,040	18,900	16,020	13,580	12,200	10,160	10,140	9,900	9,240	-66%	-11.4%
Rate	60	53	39	32	26	23	19	18	17	16	-74%	-13.9%
Kyphoplasty												
HOPD*	48,740	45,520	45,700	45,540	42,400	40,060	38,600	41,640	39,060	37,840	-22%	-2.8%
%	99%	97%	96%	91%	86%	83%	83%	79%	77%	76%	-22%	-2.8%
Rate	106	97	95	91	82	75	70	74	67	63	-40%	-5.6%
ASC	740	1,380	1,980	1,360	1,540	2,020	1,400	1,320	1,720	1,760	138%	10.1%
Rate	2	3	4	3	3	4	3	2	3	3	83%	6.9%
Office	-	-	-	2,960	5,080	6,100	6,440	9,480	9,740	9,920	235%	
Rate	-	-	-	6	10	11	12	17	17	17	183%	
Total	49,480	46,900	47,680	49,860	49,020	48,180	46,440	52,440	50,520	49,520	0%	0.0%
Rate	108	100	99	99	94	90	85	93	87	83	-23%	-2.9%
Vertebroplasty & Kyphoplasty combined												
HOPD*	70,840	65,940	61,460	59,900	55,000	51,540	48,140	51,020	48,100	46,540	-34%	-4.6%
%	92%	92%	92%	91%	88%	85%	85%	82%	80%	79%	-14%	-1.7%
Rate	155	141	127	119	106	96	88	90	83	78	-50%	-7.3%
ASC	2,040	2,380	2,460	1,720	1,840	2,240	1,620	1,660	1,920	1,980	-3%	-0.3%
Rate	4	5	5	3	4	4	3	3	3	3	-25%	-3.2%
Office	3,980	3,620	2,660	4,260	5,760	6,600	6,840	9,900	10,400	10,240	157%	11.1%
Rate	9	8	6	8	11	12	12	18	18	17	98%	7.9%
Total	76,860	72,000	66,580	65,880	62,600	60,380	56,600	62,580	60,420	58,760	-24%	-2.9%
Rate	168	153	138	131	121	113	103	111	104	99	-41%	-5.7%

* HOPD service – about 35% to 40% of procedures were performed inpatient hospital

specialty characteristics performed in vertebral augmentation procedures. While utilization data show decrease in utilization of the procedures for all specialties, radiologists increased from performing 70% of the vertebroplasty procedures in 2009 to 79% in 2018. Further, radiologists also showed increasing utilization of kyphoplasty procedures from 33% of total in 2009 increasing to 37% in 2018. In contrast, surgeons showed no significant change in utilization of vertebroplasty, but with kyphoplasty, their utilization declined from 60% in 2009 to 46% in 2018. Of interest, pain management specialists increased utilization of kyphoplasty encompassing a total of 6% in 2009 to 16% in 2018.

Regional Characteristics

Appendix Table 2 shows procedural episodes of vertebroplasty and kyphoplasty based on their Medicare contract status for various states. The decreases varied overall 12% for First Coast to 32% for Palmetto. Appendix Table 3 shows figures based on MAC status rate of vertebral augmentation per 100,000 Medicare population. In contrast to the episodes, rates show steeper declines with 35% in the

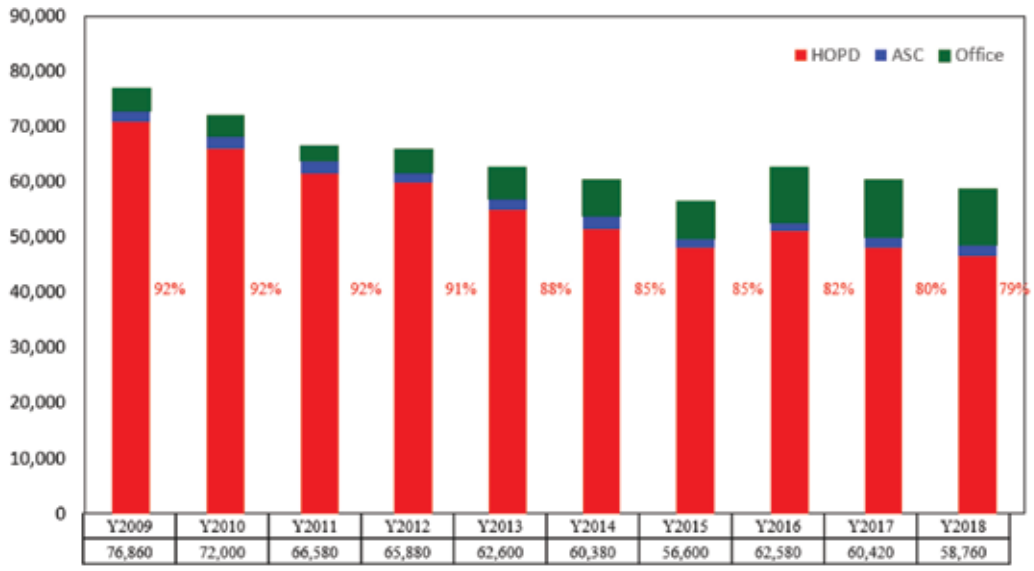

Fig. 3. *Summary of the frequency of utilization of vertebroplasty and kyphoplasty procedural episodes in the Medicare population by place of service from 2009 to 2018*

First Coast jurisdiction and almost reaching 50% in Palmetto jurisdictions.

Expenditure Characteristics

Table 4 and Appendix Tables 4 to 6 show total allowed charges by place of service and type of procedures. The overall inflation-adjusted expenditures for vertebral augmentation procedures from 2009 to 2018 showed a significant decline from $77,630,174 to $28,201,089 for a decrease of 64% with an annual decrease of 11%. Average inflation-adjusted expenditures per patient were $6,855.62 in 2009, which decreased to $6,705 with an overall decrease of 2% and an annual decrease of 0%.

Kyphoplasty interventions prior to inflation adjustment, increased 3% overall with a 0% annual increase from $312,407,735 in 2009 to $320,454,413 in 2018. However, inflation-adjusted expenditures showed a 12% decrease with an annual decrease of 1%. Expenditures attributed to physicians also decreased 6% overall with an annual decrease of 1%. Contributions of included facility expenditures, increased overall 3% for kyphoplasty with an 87% increase for office settings, 14% increase for ASC settings, and 24% decrease for hospital settings. In contrast, for vertebroplasty, there were steep declines of 71% overall with 66% for HOPDs, 85% for ASCs, and 93% for office settings. Overall expenditures for vertebral augmentation showed a net decrease of $30,102,809, or 8%, from $378,758,311 in 2009 to $348,655,502 in 2018. However, inflation-adjusted expenditures showed a decrease of $94,491,722 or 21% with an annual decrease of 3% with 2009 expenditures of $443,147,324 to $345,655,502 in 2018.

Per procedure, expenditures are shown in Table 4 and Appendix Table 4 for combined data showing expenditures per procedure of $4,607.48 in 2009 with $4,582.75 in 2018 for a net decrease. However, expenditures per vertebroplasty were $2,313.18 in 2009 with a slight increase in 2018 of $2,373.83. For kyphoplasty, the expenditures in 2009 were $4,988.94 and in 2018, $4,992 with no net increase. Overall allowed charges as shown in Table 4 and Appendix Table 5 per patient on average combined were $5,940 in 2009, decreasing to $5,889 in 2018. However, total expenditures per visit were $2,894 in 2009 for vertebroplasty with a 7% increase through 2018 of $3,092. For kyphoplasty, the expenditures were $6,538 in 2009 to $6,399 in 2018 for a slight decrease. Overall charges per patient for combined vertebroplasty and kyphoplasty procedures were $6,856 in 2009 compared to $6,705 in 2018. The total allowed charges were $3,384 in 2009 for vertebroplasty with a 3% increase to $3,490 in 2018, whereas for kyphoplasty, it was $7,491.79 for a decrease of 3% to $7,296. Further, inflation-adjusted expenditures show even further declines.

Table 4. *Total allowed charges by place of services by type of procedures.*

	Vertebro-plasty	**F2009**	**F2010**	**F2011**	**F2012**	**F2013**	**F2014**	**F2015**	**F2016**	**F2017**	**F2018**	**Change**	**GM**
Professional	HOPD	$12,376,942	$10,945,021	$8,463,958	$7,528,450	$6,562,679	$6,169,701	$4,697,920	$4,540,212	$4,527,175	$4,160,532	-66%	-11%
	ASC	$716,679	$557,622	$255,638	$193,487	$140,378	$112,762	$105,004	$178,647	$96,477	$108,837	-85%	-19%
	Office	$2,195,938	$1,898,085	$1,380,191	$740,553	$335,879	$250,032	$177,972	$214,546	$284,929	$157,922	-93%	-25%
	Total	$15,289,560	$13,400,728	$10,099,787	$8,462,490	$7,038,936	$6,532,495	$4,980,897	$4,933,405	$4,908,580	$4,427,292	-71%	-13%
Facility/ Overhead	HOPD	$43,624,295	$43,731,472	$35,000,281	$32,622,330	$29,065,302	$29,571,332	$24,814,589	$22,470,634	$22,033,282	$23,011,848	-47%	-7%
	ASC	$1,609,535	$1,383,100	$515,157	$491,187	$396,346	$354,279	$319,754	$548,198	$278,613	$290,218	-82%	-17%
	Office	$5,827,186	$5,475,982	$4,326,968	$740,553	$1,185,412	$834,814	$555,724	$658,206	$833,386	$471,731	-92%	-24%
	Total	$51,061,016	$50,590,554	$39,842,406	$33,854,069	$30,647,060	$30,760,425	$25,690,067	$23,677,038	$23,145,282	$23,773,798	-53%	-8%
Total	HOPD	$56,001,237	$54,676,493	$43,464,238	$40,150,780	$35,627,981	$35,741,033	$29,512,510	$27,010,847	$26,560,457	$27,172,380	-51%	-8%
	ASC	$2,326,214	$1,940,722	$770,795	$684,674	$536,724	$467,041	$424,758	$726,845	$375,090	$399,056	-83%	-18%
	Office	$8,023,125	$7,374,067	$5,707,159	$1,481,105	$1,521,291	$1,084,846	$733,697	$872,752	$1,118,315	$629,654	-92%	-25%
	Grand Total	$66,350,576	$63,991,282	$49,942,193	$42,316,559	$37,685,996	$37,292,920	$30,670,964	$28,610,443	$28,053,862	$28,201,089	-57%	-9%
	Grand Total#	$77,630,174	$ 73,589,974	$55,935,256	$46,125,050	$40,700,875	$39,530,495	$32,511,222	$30,040,966	$28,614,939	$28,201,089	-64%	-11%
	Kypho-plasty	**F2009**	**F2010**	**F2011**	**F2012**	**F2013**	**F2014**	**F2015**	**F2016**	**F2017**	**F2018**	**Change**	
Professional	HOPD	$29,701,587	$27,699,739	$28,288,100	$26,924,140	$24,748,506	$23,989,968	$22,938,345	$24,817,057	$22,884,965	$21,816,161	-27%	-3%
	ASC	$446,219	$891,768	$1,221,451	$816,619	$931,895	$1,233,404	$813,362	$721,669	$932,487	$971,406	118%	9%
	Office				$1,691,488	$2,987,717	$3,602,833	$3,447,953	$5,572,453	$5,483,724	$5,599,555	87%	13%
	Total	$30,147,806	$28,591,508	$29,509,552	$29,432,248	$28,668,118	$28,826,206	$27,199,660	$31,111,179	$29,301,176	$28,387,122	-6%	-1%
Facility/ Overhead	HOPD	$278,813,758	$272,012,954	$280,098,042	$283,295,232	$248,569,152	$260,668,818	$243,964,352	$294,147,875	$203,868,202	$212,132,175	-24%	-3%
	ASC	$3,446,171	$5,546,534	$7,244,403	$5,224,365	$4,596,891	$5,839,635	$4,783,363	$4,772,676	$3,937,433	$3,933,383	14%	1%
	Office	$ -	$ -	$ -	$1,691,488	$40,731,987	$46,000,267	$49,610,156	$75,078,781	$73,978,067	$76,001,733	87%	13%
	Facility Total	$282,259,929	$277,559,487	$287,342,445	$290,211,085	$293,898,030	$312,508,720	$298,357,871	$373,999,331	$281,783,702	$292,067,291	3%	0%
Total	HOPD	$308,515,345	$299,712,693	$308,386,142	$310,219,372	$273,317,658	$284,658,786	$266,902,697	$318,964,932	$226,753,167	$233,948,336	-24%	-3%
	ASC	$3,892,390	$6,438,302	$8,465,854	$6,040,984	$5,528,786	$7,073,040	$5,596,724	$5,494,344	$4,869,920	$4,904,789	26%	3%
	Office				$3,382,977	$43,719,703	$49,603,100	$53,058,109	$80,651,233	$79,461,791	$81,601,288	87%	13%
	Grand Total	$312,407,735	$306,150,995	$316,851,996	$319,643,333	$322,566,148	$341,334,926	$325,557,531	$405,110,510	$311,084,878	$320,454,413	3%	0%
	Grand Total#	$365,517,050	$352,073,644	$354,874,236	$348,411,233	$348,371,440	$361,815,021	$345,090,982	$425,366,035	$317,306,576	$320,454,413	-12%	-1%

Table 4 (cont.). *Total allowed charges by place of services by type of procedures.*

	Vertebro-plasty	F2009	F2010	F2011	F2012	F2013	F2014	F2015	F2016	F2017	F2018	Change	GM
Vertebroplasty & Kyphoplasty	Combined Total	$378,758,311	$370,142,277	$366,794,189	$361,959,892	$360,252,144	$378,627,846	$356,228,495	$433,720,953	$339,138,740	$348,655,502	-8%	-1%
	Combined Total#	$443,147,224	$425,663,619	$410,809,492	$394,536,283	$389,072,316	$401,345,517	$377,602,204	$455,407,001	$345,921,515	$348,655,502	-21%	-3%
			-4%	-3%	-4%	-1%	3%	-6%	21%	-24%	1%		
	Per 100,000 MC#	$967,549	$907,327	$850,537	$784,366	$749,657	$750,178	$687,800	$806,030	$596,416	$ 584,992	-40%	-5%
	Per MC#	$9.68	$9.07	$8.51	$7.84	$7.50	$7.50	$6.88	$8.06	$5.96	$ 5.85	-40%	-5%
	Per V/K patient#	$6,856	$7,171	$7,456	$7,096	$7,417	$7,829	$7,570	$8,860	$6,566	$ 6,705	-2%	0%

V (Vertebroplasty), K (Kyphoplasty) # - Inflation adjusted allowed charges MC - Medicare Bonfires Prof. (Professional), Fac (facility) P+T (Professional + Facility) V+K = Total is not listed

Comparative Expenditure Analysis

Based on our previous analyses, we compared the present expenditures for augmentation procedures and their changes to epidural procedures, facet joint interventions, spinal cord stimulation and vertebral augmentation procedures as shown in Fig. 4.

Discussion

From 2009 to 2018 in the Medicare FFS population, there was an overall decline in utilization patterns per 100,000 Medicare population, along with overall reductions in expenditures for vertebral augmentation procedures. Further, the rate per 100,000 Medicare population utilization patterns and inflation-adjusted expenditures showed significant decreases in overall utilization of 38% from 2009 to 2018 for a 5.2% annual decrease at the same time that there was a 20% decrease in the rate of patients undergoing these procedures, or 2.4% annual decrease. From 2009 to 2018, to the contrary, the Medicare population had rapid growth of 3% for a total increase of 30%. It should be noted that these decreases are larger than the declines of overall interventional techniques, but are nevertheless similar to adhesiolysis procedures, which have reduced at an annual rate of 12.3% from 2009 to 2018 for an overall total of 69.2% (67-73). One can compare this, by contrast, to the overall decrease in the use of interventional techniques from 2009 to 2018 of only 6.7% with an annual decline of only 0.8% per 100,000 FFS Medicare population (67-73). A contrast can be found in the utilization of spinal cord stimulation procedures and expenditures, which increased dramatically during this time period (74).

Systematic reviews comparing the RCTs by Li et al (2) with inclusion of 20 RCTs involving 2,566 patients with painful osteoporotic vertebral compression fractures (OVCFs). They concluded that balloon kyphoplasty was considered sufficient to achieve good clinical outcomes. However, percutaneous vertebroplasty was associated with no beneficial effect on the treatment of painful OVCFs compared with sham procedure. Sanli et al (1) also performed a systematic review of percutaneous cement augmentation in the treatment of osteoporotic vertebral fractures in the elderly with inclusion of 18 studies, and confirmed the efficacy of vertebral augmentation. Further, a network meta-analysis of multiple options in managing OVCFs by Zuo et al (13) including a total of 18 trials among 1,994 patients showed that percutaneous vertebral augmentation with percutaneous vertebroplasty and percutaneous kyphoplasty had better efficacy than conservative treatment. Percutaneous kyphoplasty was the first option in alleviating pain in the case of acute/subacute OVCFs for long-term and chronic OVCFs for short- and long-term, while percutaneous vertebroplasty had the most superiority in the case of the acute/subacute OVCFs for short-term. They concluded that percutaneous augmentation procedures had better performance than conservative treatment in alleviating acute, subacute and chronic OVCF pain for short- and long-term. They also showed that nerve blocks may be used for pain relief, in both the short- and long-term.

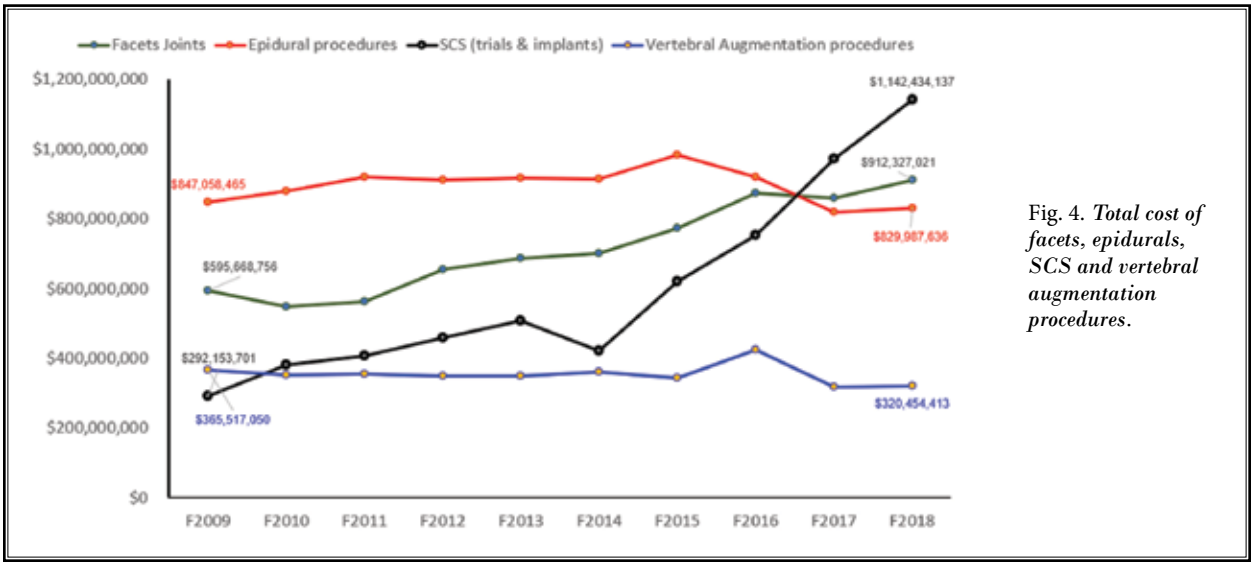

Fig. 4. *Total cost of facets, epidurals, SCS and vertebral augmentation procedures.*

The 2009 trials led various countries including Australia to no longer support augmentation procedures. The safety and efficacy of vertebroplasty for acute painful osteoporotic fractures (VAPOUR) trial (25), which was performed in Sidney, Australia, was as a result very successful at recruiting patients to a randomized trial of vertebroplasty vs. true sham. The result was positive and demonstrated the criticality of understanding placebo and the difference between active and passive control sham (77,78).

Even then, in the 2018 Cochrane vertebroplasty review, Buchbinder et al (47) concluded that the review, found "no demonstrable clinical important benefit of percutaneous vertebroplasty compared with placebo (sham procedures)" and "sensitivity analysis confirmed that open trials comparing vertebroplasty with usual care are likely to have overestimated any benefit of vertebroplasty" (46,79). The Cochrane collaboration has come under increased scrutiny and been described as a "sinking ship" (79). A group of multidisciplinary augmentation subject matter experts utilizing the RAND/UCLA method of evaluating and synthesizing evidence concluded that the data supported using augmentation in various clinical scenarios for osteoporotic VCFs (8). Subsequently, there was a multijurisdictional MedCAC that have ultimately led to appropriate LCDs (80,81).

Another formative development in the conception of vertebral augmentation has been the development of compelling evidence regarding a survivability benefit in patients treated with augmentation rather than non-surgical management. Utilizing the 100% CMS sample from a ten-year period, Ong et al (48) studied over 2 million patients with VCFs including 261,756 balloon kyphoplasty and 117,232 vertebroplasty patients demonstrating a mortality advantage at every time point for augmentation patients. The authors then applied a number needed to treat analysis on the same patient sample (82). This was then followed by a meta-analysis that demonstrated a 22% survivability advantage for VCF patients treated with augmentation (83). Chandra et al (49) reviewed the evidence including the recommendations of national societies and professional organizations. De Leacy et al (84) expanded that analysis to include the burgeoning literature on mortality in compression fracture patients.

In summary, the literature prior to 2009 has been favorable toward vertebral augmentation procedures (85,86), including a systematic review published prior to 2009 with the conclusion that vertebroplasty procedures were safe and effective in 92% of patients and kyphoplasty in 87%. The overall evidence of effectiveness and safety has been positive both in systematic reviews, as well as individual studies. In fact, the National Institute for Health and Care Excellence (NICE) in their 2013 technology appraisal guidance (50) came to the conclusion that vertebral augmentation procedures were more effective in restoring vertebral body height and pain reduction in those patients with painful OVCFs that were unhealed. Additionally, they found that kyphoplasty and vertebroplasty were both cost effective, and when compared to nonsurgical management, studies have found that patients with compression fractures had an improvement in their quality of life, as well as decreased mortality and

morbidity when augmentation procedures were employed (5,48,87-91).

Additional studies have been probed in the contribution that the opioid crisis has had on the decreased utilization of interventional techniques (53-62). For instance, a report by Best Practices in Pain Management has mentioned decreased utilization of interventional techniques (51). On top of that, present policies (53-62) may be promoting a decrease in the utilization of non-opioid techniques, which unfortunately adds fuel to the opioid epidemic.

It is imperative that modern-day gathering of evidence requires that evidence-based medicine principles be properly applied, including assessment of risk of bias and arriving at proper conclusions. However, failing to follow the principles of systematic reviews and meta-analyses, while at the same time exhibiting a confluence of interest, can be found in many high profile reviews (7,8,49,50,58-61,92-105). At the same time, there are many well-designed systematic reviews which have indeed followed appropriate published guidelines for the assessment of interventional techniques (8,10,11,15,95).

Since many of the patients receiving augmentation procedures for OVCFs are from the Medicare population, the data in this review can be assumed to provide the best utilization and expenditure data available. Nevertheless, it must be remembered that limitations of this study include the lack of inclusion of Medicare Advantage plans, which account for approximately 30% of the population. No privately insured patients were included in this analysis either.

Conclusion

This study shows a significant decline in utilization patterns of combined vertebroplasty and kyphoplasty procedures per 100,000 Medicare patients, along with reductions in overall expenditures. The inflation-adjusted total expenditures of kyphoplasty and vertebroplasty decreased 21% with an annual decline of 3%. The inflation-adjusted expenditures per 100,000 of Medicare population decreased 40% overall and 5% per year. In addition, vertebroplasty has seen substantial declines in utilization and expenditure patterns compared to kyphoplasty procedures, which have remained somewhat flat.

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Author Contributions

The study was designed by LM, SHVS, BV, MS, and JAH. Data collection and analysis was performed by VP. All authors contributed to the preparation of the manuscript, review, and approval of the content with final version.

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Appendix Table 1. *Summary of the frequency of utilization of vertebroplasty and kyphoplasty procedural episodes in the Medicare population by specialty from 2009 to 2018.*

Specialty	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Change	GM
Vertebroplasty												
Radiologists (30 or 94)	19,280	18,100	14,480	11,960	10,900	9,700	7,880	8,140	7,960	7,280	-62%	-10.3%
Percent	70%	72%	77%	75%	80%	80%	78%	80%	80%	79%	12%	1.3%
Rate	42	39	30	24	21	18	14	14	14	12	-71%	-12.8%
Surgeons (14 or 20)	4,080	3,900	2,440	2,280	1,700	1,800	1,560	1,400	1,140	1360	-67%	-11.5%
Percent	15%	16%	13%	14%	13%	15%	15%	14%	12%	15%	-1%	-0.1%
Rate	9	8	5	5	3	3	3	2	2	2	-74%	-14.0%
Pain Management (05, 09, 72 or 25)	3,440	2,740	1,760	1,520	880	620	600	560	640	460	-87%	-20.0%
Percent	13%	11%	9%	9%	6%	5%	6%	6%	6%	5%	-60%	-9.8%
Rate	8	6	4	3	2	1	1	1	1	1	-90%	-22.3%
Others	580	300	220	260	100	80	120	40	160	140	-76%	-14.6%
Rate	1	1	0	1	0	0	0	0	0	0	-81%	-17.1%
Total	27,380	25,040	18,900	16,020	13,580	12,200	10,160	10,140	9,900	9,240	-66%	-11.4%
Rate	60	53	39	32	26	23	19	18	17	16	-74%	-13.9%
Kyphoplasty												
Radiologists (30 or 94)	16,120	14,120	14,520	17,420	17,360	17,580	16,600	19,580	19,040	18,360	14%	1.5%
Percent	33%	30%	30%	35%	35%	36%	36%	37%	38%	37%	14%	1.4%
Rate	35	30	30	35	33	33	30	35	33	31	-12%	-1.5%
Surgeons (14 or 20)	29,600	28,460	27,200	26,600	25,260	23,600	22,760	23,820	22,880	22,580	-24%	-3.0%
Percent	60%	61%	57%	53%	52%	49%	49%	45%	45%	46%		
Rate	65	61	56	53	49	44	41	42	39	38	-41%	-5.8%
Pain Management (05, 09, 72 or 25)	2,960	3,780	5,080	4,940	5,860	6,480	6,620	8,580	8,080	7,880	166%	11.5%
Percent	6%	8%	11%	10%	12%	13%	14%	16%	16%	16%	166%	11.5%
Rate	6	8	11	10	11	12	12	15	14	13	105%	8.3%
Others	800	600	880	900	540	520	460	460	520	700	-13%	-1.5%
Rate	2	1	2	2	1	1	1	1	1	1	-33%	-4.3%
Total	49,480	46,960	47,680	49,860	49,020	48,180	46,440	52,440	50,520	49,520	0%	0.0%
Rate	108	100	99	99	94	90	85	93	87	83	-23%	-2.9%
Vertebroplasty & Kyphoplasty combined												
Radiologists (30 or 94)	35,400	32,220	29,000	29,380	28,260	27,280	24,480	27,720	27,000	25,640	-28%	-3.5%
Percent	46%	45%	44%	45%	45%	45%	43%	44%	45%	44%	-5%	-0.6%
Rate	77	69	60	58	54	51	45	49	47	43	-44%	-6.3%
Surgeons (14 or 20)	33,680	32,360	29,640	28,880	26,960	25,400	24,320	25,220	24,020	23,940	-29%	-3.7%
Pericent	44%	45%	45%	44%	43%	42%	43%	40%	40%	41%	-7%	-0.8%
Rate	74	69	61	57	52	47	44	45	41	40	-45%	-6.5%
Pain Management (05, 09, 72 or 25)	6,400	6,520	6,840	6,460	6,740	7,100	7,220	9,140	8,720	8,340	30%	3.0%
Percent	8%	9%	10%	10%	11%	12%	13%	15%	14%	14%	70%	6.1%
Others	1,380	900	1,100	1,160	640	600	580	500	680	840	-39%	-5.4%
Rate	3	2	2	2	1	1	1	1	1	1	-53%	-8.1%
V&K total	76,860	72,000	66,580	65,880	62,600	60,380	56,600	62,580	60,420	58,760	-24%	-2.9%
Rate	168	153	138	131	121	113	103	111	104	99	-41%	-5.7%

Appendix Table 2. *Summary of the frequency of utilization of vertebroplasty and kyphoplasty procedural episodes in the Medicare population by state and 2016 Medicare carrier from 2009 to 2018.*

State	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Change	GM
Cahaba												
Alabama	1,640	1,180	1,160	1,400	1,220	1,420	1,200	940	940	1,240	-24%	-3.1%
Georgia	2,380	2,580	1,880	2,200	1,760	2,000	1,700	1,700	1,660	1,960	-18%	-2.1%
Tennessee	1,600	1,500	1,580	1,640	1,260	1,100	1,540	1,300	1,280	1,100	-31%	-4.1%
Cahaba Total	5,620	5,260	4,620	5,240	4,240	4,520	4,440	3,940	3,880	4,300	-23%	-2.9%
CGS												
Kentucky	1,560	1,520	1,440	1,400	1,920	1,260	960	1,300	1,180	1,160	-26%	-3.2%
Ohio	3,040	2,580	2,540	2,380	2,620	2,580	2,300	2,660	2,360	2,320	-24%	-3.0%
CGS total	1,480	1,060	1,100	980	700	1,320	1,340	1,360	1,180	1,160	-22%	-2.7%
First Coast												
Florida	7,700	7,800	7,220	6,700	7,000	6,180	6,160	7,260	7,520	6,760	-12%	-1.4%
NGS												
Connecticut	860	460	620	640	480	260	460	520	440	580	-33%	-4.3%
Illinois	3,340	3,040	3,320	3,380	2,800	2,320	2,540	2,920	2,620	2,460	-26%	-3.3%
Maine	440	260	280	340	360	460	340	300	580	240	-45%	-6.5%
Massachusetts	1,440	1,620	1,340	1,140	1,480	1,480	1,260	1,120	1,540	780	-46%	-6.6%
Minnesota	1,100	740	480	340	340	360	280	220	340	320	-71%	-12.8%
New Hampshire	300	300	280	460	260	440	200	340	360	380	27%	2.7%
New York	1,900	1,800	1,880	1,920	1,360	1,380	1,560	1,900	1,660	1,580	-17%	-2.0%
Rhode Island	80	160	120	140	100	60	80	100	160	100	25%	2.5%
Vermont	120	100	100	60	20	-	-	20	200	20	-83%	-18.1%
Wisconsin	1,440	820	1,060	820	860	640	600	760	640	660	-54%	-8.3%
NGS total	11,020	9,300	9,480	9,240	8,060	7,400	7,320	8,200	8,540	7,120	-35%	-4.7%
Noridian												
Alaska	60	60	-	-	-	20	20	-	40	-	-100%	-100.0%
Arizona	980	1,180	960	600	680	680	780	1,060	880	920	-6%	-0.7%
California	4,820	4,480	4,780	4,060	3,420	3,960	3,600	4,300	3,780	3,280	-32%	-4.2%
Idaho	680	540	520	220	240	460	260	260	280	280	-59%	-9.4%
Montana	200	120	180	60	40	80	100	40	160	160	-20%	-2.4%
Nevada	460	480	480	600	660	420	400	120	340	500	9%	0.9%
North Dakota	320	400	300	80	280	120	40	100	160	300	-6%	-0.7%
Oregon	320	380	380	140	200	180	260	260	260	320	0%	0.0%
South Dakota	460	420	320	60	80	220	160	120	80	200	-57%	-8.8%
Utah	440	380	280	360	260	300	400	300	420	620	41%	3.9%
Washington	1,880	1,240	860	520	460	900	860	780	580	980	-48%	-7.0%
Wyoming	160	180	120	80	60	80		100	60	80	-50%	-7.4%
Noridian Total	10,780	9,860	9,180	6,780	6,380	7,420	6,880	7,440	7,040	7,640	-29%	-3.8%
Novitas												
Arkansas	1,440	1,020	1,340	1,440	1,600	1,000	1,560	1,220	1,500	1,040	-28%	-3.6%
Colorado	520	560	680	740	620	660	680	660	720	640	23%	2.3%
Delaware	80	320	300	280	180	200	180	180	40	80	0%	0.0%
DC	20	20	20	60	40	20	40	40	20	20	0%	0.0%
Louisiana	800	1,140	760	1,180	800	980	900	940	840	680	-15%	-1.8%
Maryland	900	1,020	960	980	840	680	600	740	1,060	1,180	31%	3.1%

Appendix Table 2 (cont.). *Summary of the frequency of utilization of vertebroplasty and kyphoplasty procedural episodes in the Medicare population by state and 2016 Medicare carrier from 2009 to 2018.*

State	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Change	GM
Mississippi	940	820	820	1,020	760	1,060	900	1,160	1,080	800	-15%	-1.8%
New Jersey	1,080	1,120	780	940	960	740	760	860	800	920	-15%	-1.8%
New Mexico	340	260	340	280	180	200	160	200	220	300	-12%	-1.4%
Oklahoma	1,500	1,460	1,840	1,920	1,880	1,840	1,440	1,800	1,740	1,660	11%	1.1%
Pennsylvania	2,740	2,380	2,420	1,840	2,260	1,700	1,400	1,780	1,760	1,620	-41%	-5.7%
Texas	6,900	6,980	6,020	6,660	5,240	6,340	5,140	5,720	5,120	5,480	-21%	-2.5%
Novitas total	17,260	17,100	16,280	17,340	15,360	15,420	13,760	15,300	14,900	14,420	-16%	-2.0%
Palmetto GBA												
North Carolina	3,480	3,040	2,640	2,800	2,320	2,100	2,340	2,140	1,840	2,100	-40%	-5.5%
South Carolina	1,600	1,940	1,520	1,500	1,540	1,480	900	1,620	1,020	1,380	-14%	-1.6%
Virginia	3,060	2,280	1,900	2,040	2,240	2,620	2,240	2,240	2,260	2,080	-32%	-4.2%
West Virginia	480	320	280	320	400	280	360	560	440	280	-42%	-5.8%
Palmetto Total	8,620	7,580	6,340	6,660	6,500	6,480	5,840	6,560	5,560	5,840	-32%	-4.2%
WPS												
Indiana	2,980	2,280	2,360	1,980	2,000	1,800	1,720	2,100	1,760	1,680	-44%	-6.2%
Iowa	580	680	380	580	580	660	400	420	520	540	-7%	-0.8%
Kansas	1,600	1,640	1,400	1,680	2,040	1,600	1,740	2,060	1,480	1,400	-13%	-1.5%
Michigan	2,520	3,160	2,360	2,380	2,580	2,540	2,360	2,500	2,540	2,520	0%	0.0%
Missouri	2,320	2,260	2,220	2,400	2,300	1,820	2,180	1,980	2,340	1,980	-15%	-1.7%
Nebraska	1,100	840	500	940	880	600	480	800	740	940	-15%	-1.7%
WPS total	11,100	10,860	9,220	9,960	10,380	9,020	8,880	9,860	9,380	9,060	-18%	-2.2%
US	76,860	72,000	66,580	65,880	62,600	60,380	56,600	62,580	60,420	58,760	-24%	0.0%

Appendix Table 3. *Summary of the utilization of vertebroplasty and kyphoplasty procedural episode rates in the Medicare population by state and 2016 MACs from 2009 to 2018.*

State	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Change	GM
Cahaba												
Alabama	198	140	134	159	135	153	126	97	93	121	-39%	-5.4%
Georgia	199	209	147	167	129	140	115	112	102	117	-41%	-5.8%
Tennessee	155	142	145	148	109	93	127	105	99	83	-46%	-6.7%
Cahaba Total	184	168	143	158	124	128	122	106	99	107	-42%	-5.9%
CGS												
Kentucky	210	200	185	176	237	152	114	151	132	127	-39%	-5.4%
Ohio	163	136	131	121	131	126	110	123	105	101	-38%	-5.1%
CGS Total	131	93	95	83	59	108	108	105	87	84	-36%	-4.9%
First Coast												
Florida	234	231	208	190	190	162	156	180	175	153	-35%	-4.6%
NGS												
Connecticut	154	81	107	109	84	45	78	82	67	87	-44%	-6.2%
Illinois	185	165	177	177	149	120	129	141	122	112	-39%	-5.4%
Maine	170	98	103	123	127	158	114	98	180	72	-57%	-9.0%
Massachusetts	139	153	124	103	136	132	110	92	121	60	-57%	-8.9%
Minnesota	143	94	60	41	40	42	31	24	35	32	-78%	-15.3%
New Hampshire	138	134	122	199	111	181	80	128	128	131	-5%	-0.6%
New York	65	60	62	62	45	45	49	57	48	44	-31%	-4.1%
Rhode Island	44	87	65	74	55	32	42	49	76	46	4%	0.5%
Vermont	111	90	87	51	17	-	-	15	144	14	-87%	-20.6%
Wisconsin	161	90	114	86	88	63	58	72	58	58	-64%	-10.8%
NGS Total	126	104	104	100	87	78	76	81	81	66	-48%	-7.0%
Noridian												
Alaska	96	91	-	-	-	27	26	-	44	-	-100%	-100.0%
Arizona	109	127	100	61	67	65	71	93	72	72	-34%	-4.4%
California	104	94	98	81	69	77	68	76	63	54	-49%	-7.1%
Idaho	306	235	219	91	94	173	94	92	91	87	-71%	-13.0%
Montana	121	71	104	34	22	42	51	20	74	72	-41%	-5.7%
Nevada	134	135	129	158	169	103	93	26	69	98	-27%	-3.5%
North Dakota	296	366	273	72	252	106	35	84	129	235	-21%	-2.5%
Oregon	53	61	59	21	29	25	35	34	32	38	-28%	-3.6%
South Dakota	342	308	231	43	56	149	105	77	48	117	-66%	-11.2%
Utah	161	134	96	120	86	95	122	87	113	160	0%	0.0%
Washington	200	128	86	51	44	82	75	66	45	74	-63%	-10.4%
Wyoming	205	225	146	95	69	89	-	105	59	75	-63%	-10.5%
Noridian Total	128	113	102	74	69	78	69	71	63	66	-48%	-7.0%
Novitas												
Arkansas	277	192	247	261	284	174	266	205	243	166	-40%	-5.5%
Colorado	86	90	105	111	90	92	91	84	85	73	-16%	-1.9%
Delaware	55	214	195	178	111	118	103	100	21	40	-28%	-3.6%
DC	26	26	25	74	56	28	54	45	22	22	-17%	-2.1%
Louisiana	119	166	108	164	109	130	117	119	101	80	-33%	-4.3%
Maryland	118	130	119	118	104	82	70	80	108	117	-1%	-0.1%

Appendix Table 3 (cont.). *Summary of the utilization of vertebroplasty and kyphoplasty procedural episode rates in the Medicare population by state and 2016 MACs from 2009 to 2018.*

State	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Change	GM
Mississippi	193	165	162	197	143	195	162	207	186	135	-30%	-3.8%
New Jersey	83	84	58	68	71	54	54	58	52	58	-30%	-3.9%
New Mexico	112	83	105	85	54	58	45	54	55	73	-35%	-4.6%
Oklahoma	253	242	299	307	296	284	218	239	246	230	-9%	-1.1%
Pennsylvania	122	104	105	78	96	71	57	70	67	60	-50%	-7.5%
Texas	238	233	194	209	160	187	147	157	132	136	-43%	-6.0%
Novitas Total	163	157	146	152	134	130	113	120	112	105	-35%	-4.7%
Palmetto GBA												
North Carolina	240	204	172	179	141	123	133	121	98	109	-55%	-8.4%
South Carolina	214	251	190	183	178	165	97	172	101	133	-38%	-5.2%
Virginia	276	200	162	170	185	210	175	166	158	141	-49%	-7.1%
West Virginia	127	84	73	82	100	69	87	134	103	65	-49%	-7.3%
Palmetto Total	234	200	163	167	158	152	133	147	117	120	-49%	-7.2%
WPS												
Indiana	303	227	230	189	185	163	152	183	146	136	-55%	-8.5%
Iowa	113	131	73	109	107	119	71	73	87	88	-22%	-2.8%
Kansas	376	379	319	375	450	345	367	423	290	268	-29%	-3.7%
Michigan	156	191	140	138	143	138	125	132	128	124	-20%	-2.5%
Missouri	235	225	217	231	217	167	196	174	198	164	-30%	-3.9%
Nebraska	399	301	177	327	304	203	158	255	225	278	-30%	-3.9%
WPS total	231	222	185	196	199	169	162	177	162	153	-34%	-4.5%
US	168	153	138	131	121	113	103	111	104	99	-41%	-5.7%

Appendix Table 4. Average allowed expenditure per procedure.

Vertebroplasty	**Y2009**	**Y2010**	**Y2011**	**Y2012**	**Y2013**	**Y2014**	**Y2015**	**Y2016**	**Y2017**	**Y2018**	**Change**	**GM**
Professional Average	$455.59	$433.68	$438.74	$422.28	$420.49	$429.77	$376.77	$388.46	$365.22	$372.67	-18%	-2%
Facility												
HOPD	$1,589.81	$1,708.26	$1,800.43	$1,830.66	$1,856.02	$2,050.72	$1,991.54	$1,927.16	$1,771.16	$2,061.99	30%	3%
ASC	$1,045.15	$1,097.70	$919.92	$1,067.80	$1,238.58	$1,476.16	$1,229.82	$1,245.90	$1,160.89	$967.39	-7%	-1%
Office	$1,272.31	$1,355.44	$1,432.77	$420.77	$1,559.75	$1,545.95	$1,111.45	$1,097.01	$1,096.56	$1,123.17	-12%	-1%
Facility Average	$1,521.48	$1,637.23	$1,730.77	$1,689.32	$1,830.77	$2,023.71	$1,943.27	$1,864.33	$1,722.12	$2,001.16	32%	3%
Total (P+F.)												
HOPD	$2,040.86	$2,135.80	$2,235.81	$2,253.13	$2,275.09	$2,478.57	$2,368.58	$2,316.54	$2,135.08	$2,434.80	19%	2%
ASC	$1,510.53	$1,540.26	$1,376.42	$1,488.42	$1,677.26	$1,946.00	$1,633.68	$1,651.92	$1,562.88	$1,330.19	-12%	-1%
Office	$1,751.77	$1,825.26	$1,889.79	$841.54	$2,001.70	$2,008.97	$1,467.39	$1,454.59	$1,471.47	$1,499.18	-14%	-2%
V Total	$1,977.07	$2,070.92	$2,169.51	$2,111.60	$2,251.25	$2,453.48	$2,320.04	$2,252.79	$2,087.34	$2,373.83	20%	2%
V Total#	$2,313.18	$2,381.55	$2,429.85	$2,301.65	$2,431.35	$2,600.69	$2,459.25	$2,365.43	$2,129.09	$2,373.83	3%	0%
		3%	2%	-5%	6%	7%	-5%	-4%	-10%	11%		
Kyphoplasty	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018	Change	GM
Professional	$481.44	$485.10	$497.13	$470.77	$471.67	$476.78	$455.15	$453.25	$438.51	$442.17	-8%	-1%
Facility												
HOPD	$4,520.33	$4,767.14	$4,917.45	$4,952.71	$4,734.65	$5,180.22	$4,863.72	$5,363.75	$3,886.16	$4,294.17	-5%	-1%
ASC	$3,666.14	$2,950.28	$3,018.50	$3,185.59	$2,298.45	$2,373.84	$2,749.06	$3,268.96	$2,008.89	$1,855.37	-49%	-7%
Office				$459.64	$6,485.99	$5,989.62	$6,311.72	$6,084.18	$5,965.97	$5,993.83	-8%	-2%
Facility Average	$4,507.50	$4,709.19	$4,840.67	$4,641.89	$4,835.44	$5,168.85	$4,992.60	$5,448.71	$4,217.06	$4,549.33	1%	0%
Total (P+F.)												
HOPD	$5,001.87	$5,252.59	$5,414.08	$5,423.42	$5,206.05	$5,656.97	$5,321.03	$5,816.28	$4,322.40	$4,735.80	-5%	-1%
ASC	$4,140.84	$3,424.63	$3,527.44	$3,683.53	$2,764.39	$2,875.22	$3,216.51	$3,763.25	$2,484.65	$2,313.58	-44%	-6%
Office				$919.29	$6,961.74	$6,458.74	$6,750.40	$6,535.76	$6,408.21	$6,435.43	-8%	-2%
K Total	$4,988.94	$5,194.28	$5,337.80	$5,112.66	$5,307.11	$5,645.63	$5,447.75	$5,901.96	$4,655.57	$4,991.50	0%	0%
K Total#	$5,837.07	$5,973.42	$5,978.34	$5,572.80	$5,731.68	$5,984.37	$5,774.61	$6,197.06	$4,748.68	$4,991.50	-14%	-2%
		2%	0%	-7%	3%	4%	-4%	7%	-23%	5%		
Combined (V+K)	$4,607.48	$4,738.02	$4,986.76	$4,778.78	$5,018.99	$5,304.59	$5,174.05	$5,598.81	$4,310.01	$4,582.75	-1%	0%
Inflation		2.8%	5.2%	-4.2%	5.0%	5.7%	-2.5%	8.2%	-23.0%	6.3%		

- Inflation adjusted allowed charges

Appendix Table 5. *Average allowed charges per visit*.

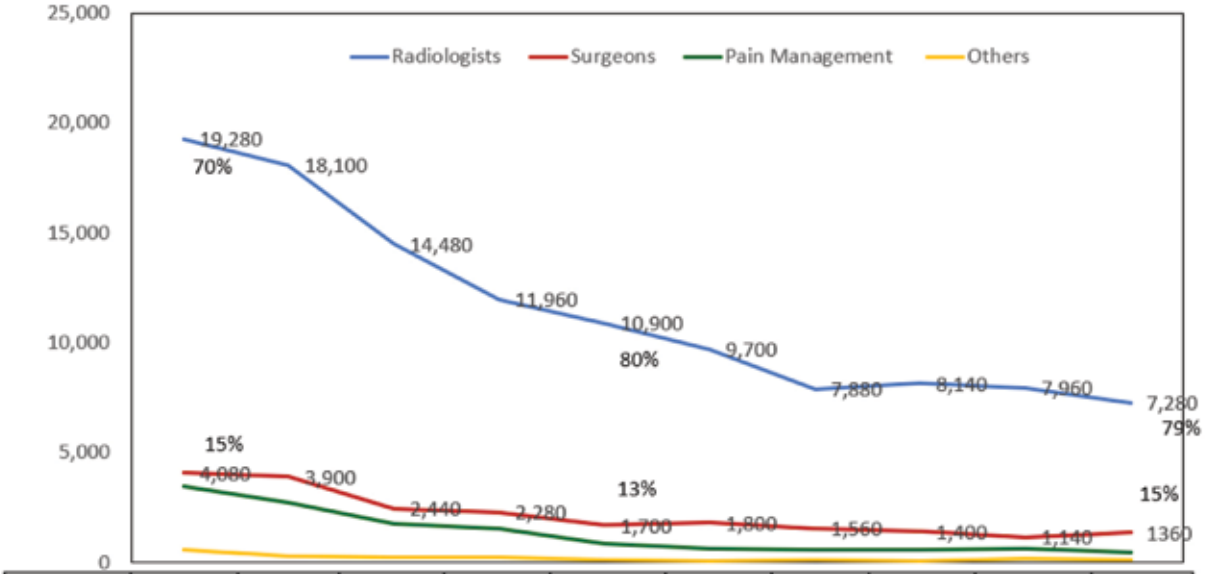
Vertebroplasty	**Y2009**	**Y2010**	**Y2011**	**Y2012**	**Y2013**	**Y2014**	**Y2015**	**Y2016**	**Y2017**	**Y2018**	**Change**	**GM**
Professional average	$570.08	$556.51	$555.54	$543.16	$535.69	$553.60	$491.21	$509.65	$499.86	$485.45	-15%	-2%
Facility												
HOPD	$2,019.64	$2,240.34	$2,317.90	$2,353.70	$2,382.40	$2,659.29	$2,601.11	$2,507.88	$2,459.07	$2,688.30	33%	3%
ASC	$1,277.41	$1,411.33	$1,119.91	$1,364.41	$1,415.52	$1,610.36	$1,453.43	$1,713.12	$1,393.07	$1,319.17	3%	0%
Office	$1,471.51	$1,529.60	$1,651.51	$544.52	$1,796.08	$1,814.81	$1,462.43	$1,645.52	$1,262.71	$1,387.44	-6%	-1%
Facility Average	$1,903.84	$2,100.94	$2,191.55	$2,172.92	$2,332.35	$2,606.82	$2,533.54	$2,445.98	$2,356.95	$2,606.78	37%	4%
Total (P+F)												
HOPD	$2,592.65	$2,801.05	$2,878.43	$2,896.88	$2,920.33	$3,214.12	$3,093.55	$3,014.60	$2,964.34	$3,174.34	22%	2%
ASC	$1,846.20	$1,980.33	$1,675.64	$1,901.87	$1,916.87	$2,122.91	$1,930.72	$2,271.39	$1,875.45	$1,813.89	-2%	0%
Office	$2,026.04	$2,059.80	$2,178.30	$1,089.05	$2,304.99	$2,358.36	$1,930.78	$2,181.88	$1,694.42	$1,851.92	-9%	-1%
Total	$2,473.92	$2,657.45	$2,747.10	$2,716.08	$2,868.04	$3,160.42	$3,024.75	$2,955.62	$2,856.81	$3,092.22	25%	3%
Total#	$2,894.49	$3,056.06	$3,076.75	$2,960.53	$3,097.48	$3,350.04	$3,206.23	$3,103.41	$2,913.94	$3,092.22	7%	1%
		6%	1%	-4%	5%	8%	-4%	-3%	-6%	6%		
Kyphoplasty	**Y2009**	**Y2010**	**Y2011**	**Y2012**	**Y2013**	**Y2014**	**Y2015**	**Y2016**	**Y2017**	**Y2018**	**Change**	**GM**
Professional average	$630.97	$637.63	$646.01	$617.29	$612.04	$622.33	$581.44	$616.06	$572.51	$566.84	-10%	-1%
Facility												
HOPD	$5,927.16	$6,250.30	$6,400.78	$6,509.54	$6,158.80	$6,809.53	$6,271.58	$7,306.21	$5,153.39	$5,547.39	-6%	-1%
ASC	$4,656.99	$4,201.92	$3,773.13	$3,898.78	$3,024.27	$2,979.41	$3,416.69	$3,728.65	$2,289.21	$2,234.88	-52%	-8%
Office				$599.82	$8,212.09	$7,565.83	$7,655.89	$8,379.33	$7,472.53	$7,539.85	-8%	-2%
Facility Average	$5,907.49	$6,190.00	$6,290.33	$6,086.64	$6,274.51	$6,746.73	$6,377.89	$7,405.93	$5,505.74	$5,832.01	-1%	0%
Total (P+F)												
HOPD	$6,558.57	$6,886.78	$7,047.22	$7,128.20	$6,771.99	$7,436.23	$6,861.25	$7,922.63	$5,731.88	$6,117.90	-7%	-1%
ASC	$5,259.99	$4,877.50	$4,409.30	$4,508.20	$3,637.36	$3,608.69	$3,997.66	$4,292.46	$2,831.35	$2,786.81	-47%	-7%
Office				$1,199.64	$8,814.46	$8,158.40	$8,187.98	$9,001.25	$8,026.44	$8,095.37	-8%	-2%
Total	$6,538.46	$6,827.63	$6,936.34	$6,703.93	$6,886.55	$7,369.06	$6,959.33	$8,021.99	$6,078.25	$6,398.85	-2%	0%
Total#	$7,650.00	$7,851.78	$7,768.70	$7,307.28	$7,437.48	$7,811.21	$7,376.89	$8,423.09	$6,199.82	$6,398.85	-16%	-2%
		3%	-1%	-6%	2%	5%	-6%	14%	-26%	3%		
Combined (V+K)	$5,940.31	$6,176.20	$6,432.97	$6,236.74	$6,486.70	$6,905.46	$6,633.91	$7,567.41	$5,670.84	$5,889.45	-1%	0%
		4.0%	4.2%	-3.1%	4.0%	6.5%	-3.9%	14.1%	-25.1%	3.9%		

- Inflation adjusted allowed charges

Appendix Table 6. *Average allowed charges per patient.*

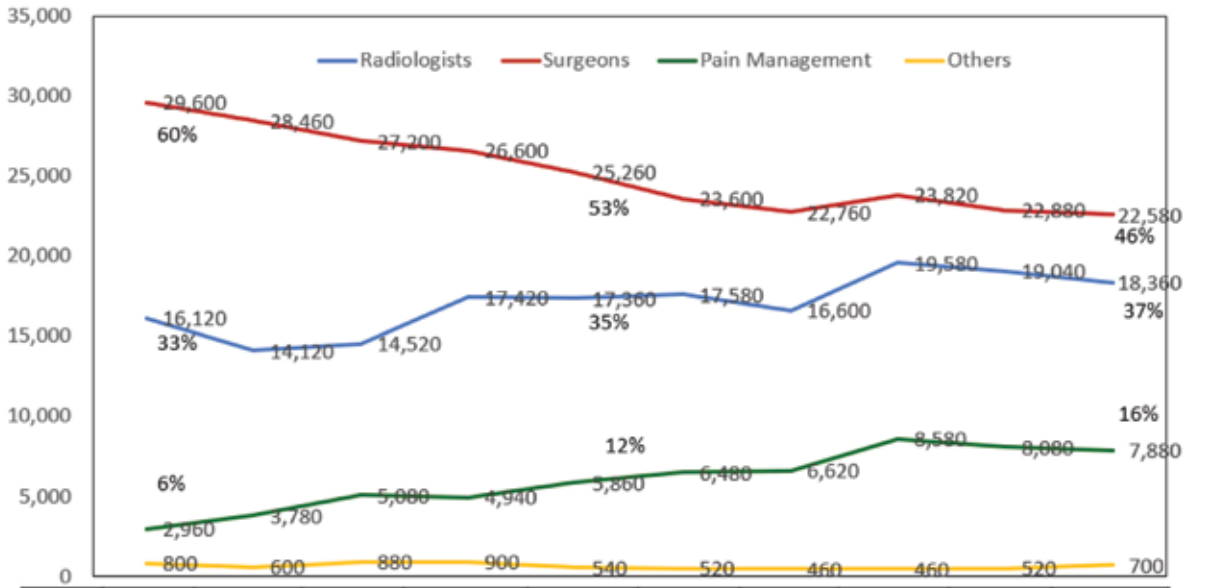
Vertebroplasty	**Y2009**	**Y2010**	**Y2011**	**Y2012**	**Y2013**	**Y2014**	**Y2015**	**Y2016**	**Y2017**	**Y2018**	**Change**	**GM**
Professional average	$666.50	$664.06	$658.40	$629.65	$628.48	$640.44	$553.43	$607.56	$582.97	$547.93	-18%	-2%
Facility												
HOPD	$2,347.92	$2,653.61	$2,742.97	$2,709.50	$2,800.13	$3,061.21	$2,926.25	$2,980.19	$2,861.47	$3,004.16	28%	3%
ASC	$1,437.08	$1,646.55	$1,170.81	$1,637.29	$1,651.44	$2,214.24	$1,598.77	$1,827.33	$1,547.85	$1,813.86	26%	3%
Office	$1,798.51	$1,914.68	$2,021.95	$673.23	$2,043.81	$2,196.88	$1,736.64	$2,350.74	$1,543.31	$1,814.35	1%	0%
Facility average	$2,225.85	$2,506.97	$2,597.29	$2,518.90	$2,736.34	$3,015.73	$2,854.45	$2,915.89	$2,748.85	$2,942.30	32%	3%
Total (P+F.)												
HOPD	$3,014.06	$3,317.75	$3,406.29	$3,334.78	$3,432.37	$3,699.90	$3,480.25	$3,582.34	$3,449.41	$3,547.31	18%	2%
ASC	$2,076.98	$2,310.38	$1,751.81	$2,282.25	$2,236.35	$2,919.01	$2,123.79	$2,422.82	$2,083.83	$2,494.10	20%	2%
Office	$2,476.27	$2,578.35	$2,666.90	$1,346.46	$2,622.92	$2,854.86	$2,292.80	$3,116.97	$2,070.95	$2,421.75	-2%	0%
Total	$2,892.35	$3,171.02	$3,255.68	$3,148.55	$3,364.82	$3,656.17	$3,407.88	$3,523.45	$3,331.81	$3,490.23	21%	2%
Total#	$3,384.05	$3,646.68	$3,646.37	$3,431.92	$3,634.01	$3,875.54	$3,612.36	$3,699.63	$3,398.45	$3,490.23	3%	0%
		8%	0%	-6%	6%	7%	-7%	2%	-8%	3%		
Kyphoplasty	**Y2009**	**Y2010**	**Y2011**	**Y2012**	**Y2013**	**Y2014**	**Y2015**	**Y2016**	**Y2017**	**Y2018**	**Change**	**GM**
Professional average	$722.97	$729.75	$742.19	$698.11	$694.82	$702.05	$665.35	$718.84	$662.02	$646.34	-11%	-1%
Facility												
HOPD	$6,793.71	$7,169.56	$7,343.94	$7,369.80	$6,966.62	$7,644.25	$7,183.87	$8,433.14	$5,885.34	$6,242.85	-8%	-1%
ASC	$5,221.47	$4,473.01	$4,471.85	$4,213.20	$3,536.07	$3,517.85	$3,737.00	$3,977.23	$2,696.87	$2,458.36	-53%	-8%
Office				$682.05	$9,516.82	$8,679.30	$8,796.13	$10,427.61	$9,065.94	$9,112.92	-4%	-1%
Facility average	$6,768.82	$7,084.21	$7,226.92	$6,883.56	$7,123.07	$7,611.03	$7,298.38	$8,641.39	$6,366.55	$6,649.98	-2%	0%
Total (P+F.)												
HOPD	$7,517.43	$7,899.65	$8,085.64	$8,070.22	$7,660.25	$8,347.76	$7,859.33	$9,144.64	$6,545.99	$6,884.88	-8%	-1%
ASC	$5,897.56	$5,192.18	$5,225.84	$4,871.76	$4,252.91	$4,260.87	$4,372.44	$4,578.62	$3,335.56	$3,065.49	-48%	-7%
Office				$1,364.10	$10,214.88	$9,359.08	$9,407.47	$11,201.56	$9,737.96	$9,784.33	-4%	-1%
Total	$7,491.79	$7,813.96	$7,969.11	$7,581.67	$7,817.89	$8,313.08	$7,963.74	$9,360.22	$7,028.58	$7,296.32	-3%	0%
Total#	$8,765.40	$8,986.06	$8,925.41	$8,264.02	$8,443.32	$8,811.86	$8,441.56	$9,828.24	$7,169.15	$7,296.32	-17%	-2%
		3%	-1%	-7%	2%	4%	-4%	16%	-27%	2%		
Combined (V+K)	$6,855.62	$7,170.88	$7,455.71	$7,095.98	$7,416.55	$7,829.60	$7,570.21	$8,860.06	$6,566.47	$6,704.91	-2%	0%
		4.6%	4.0%	-4.8%	4.5%	5.6%	-3.3%	17.0%	-25.9%	2.1%		

- Inflation adjusted allowed charges



	2009	2010	1011	2012	2013	2014	2015	2016	2017	2018
Total	27,380	25,040	18,900	16,020	13,580	12,200	10,160	10,140	9,900	9,240

Appendix Fig. 1A. *Vertebroplasty procedural episodes in the Medicare population by specialty from 2009 to 2018.*



	Y2009	Y2010	Y2011	Y2012	Y2013	Y2014	Y2015	Y2016	Y2017	Y2018
Total	49,480	46,960	47,680	49,860	49,020	48,180	46,440	52,440	50,520	49,520

Appendix Fig. 1B. *Kyphoplasty procedural episodes in the Medicare population by specialty from 2009 to 2018.*