2024 Hip and Knee Implant Review

A publication and on-line information service on cost and quality issues in orthopedics.

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The number of US hip and knee implant procedures performed in the United States increased between 2022 and 2023 by 4.6% to 2.15 million according to estimates from iData Research, Inc. of Vancouver, British Columbia. The number of hip replacement procedures grew 3.8% to approximately 793 thousand, and knee replacements grew 5.1% to approximately 1.36 million. The fastest growing segments were revision knee procedures (up 8.4% over 2022) and primary knees (up 4.9% to 1.13 million). Revision knees outnumber revision hips but both represent approximately 10% of annual primary procedures.

The top 10 U.S. hospitals performing Medicare inpatient and outpatient hip and knee replacement procedures contains many familiar names. Three hospitals; Hospital for Special Surgery, New England Baptist and Christiana Care Wilmington Hospital have been in the top 10 joint programs for the previous 10 years. Although the methods of providing services may vary between hospitals, the percentage of outpatient cases ranged from a low of 36% at NYU Langone's Tisch Hospital to a high of 83% at Christiana Care Wilmington Hospital.

Estimates of U.S. Hospital Hip and Knee Replacement Procedures: 2022-2023

	2022 Estimated Procedures	2023 Estimated Procedures	% Change 2022-2023
Hip	**763,691**	**793,082**	**3.8%**
Total	579,488	605,605	4.5%
Partial	101,982	102,404	0.4%
Revision	77,735	80,929	4.1%
Resurfacing	4,486	4,144	-7.6%
Knee	**1,293,438**	**1,359,110**	**5.1%**
Primary	1,078,392	1,131,697	4.9%
Unicondylar + PFJ	72,772	74,308	2.1%
Revision	129,565	140,414	8.4%
Patello-Femoral	12,709	12,691	-0.1%
Total Hips and Knees	**2,057,129**	**2,152,192**	**4.6%**

Source: iData Research, Inc., Vancouver, British Columbia

Top 10 U.S. Hospitals with Medicare Inpatient and Outpatient Hip and Knee Replacements 2023

		2023 Medicare Cases	% OP	10 Year Top 10
Hospital for Special Surgery (3016392)	New York, NY	7,377	49%	10
New England Baptist Hospital (3007473)	Roxbury Crossing, MA	2,604	51%	10
HOAG Orthopedic Institute (3026339)	Irvine, CA	1,831	77%	8
Lehigh Valley Hospital - Cedar Crest (3003945)	Allentown, PA	1,808	76%	2
NorthShore University HealthSystem Evanston Hospital (3010906)	Evanston, IL	1,781	67%	3
Morristown Medical Center (3007715)	Morristown, NJ	1,774	78%	3
Mayo Clinic Hospital - Saint Marys Campus (3004664)	Rochester, MN	1,578	71%	9
NYU Langone's Tisch Hospital (3016487)	New York, NY	1,507	36%	1
North Shore University Hospital (3012994)	Manhasset, NY	1,494	46%	2
Christiana Care Wilmington Hospital (3003826)	Wilmington, DE	1,377	83%	10

Cases with DRGs 480-482. Source: Dexur compiled from CMS data for CY 2023 has same 3-digit roots with 6th digit of 5, B, C, or D.
HOAG Orthopedic Institute, Morristown Medical Center, Orlando Health Orlando Regional Medical Center, NorthShore University HealthSystem Evanston Hospital, Lehigh Valley Hospital - Cedar Crest, Atrium Health Mercy, O.A.S.I.S Hospital

The Shift to Outpatient Joint Replacements

Medicare reimbursement for TKA and total hip replacements began in 2020 and 2021 respectively and the shift to less expensive outpatient surgery departments (HOPDs), or ambulatory surgery centers (ASCs) has been dramatic.

According to Dexur, the percentage of Medicare joint replacements that were performed in hospital outpatient facilities increased from approximately 14% to approximately 72% in 2023.

The movement to outpatient procedures has not been uniform across individual states. States with the highest outpatient penetration, like Maine, Delaware, Idaho and New Hampshire reported 80+% of their joint replacements being performed in outpatient settings. The lowest were hospitals in Oklahoma, New York, Massachusetts and West Virginia, reporting 51%-62% of Medicare procedures as outpatients. The large variances could be explained by the prevalence of hospital owned ASCs or physician owned hospitals. Physician-owned facilities don't have the incentive to push these cases to outpatient sites of care. Interestingly, the percentage of outpatient procedures in high-volume states decreased slightly in all states in 2023 while the percentage in the low-volume states increased or was flat.

Percentage of Medicare Joint Replacements that were Outpatient

Source: www.dexur.com

Medicare Hospital Outpatient Joint Replacements, by State

State	2018	2019	2020	2021	2022	2023	Chg 18-23
Overall Average	13.6%	18.2%	33.0%	56.6%	68.8%	71.8%	58.2%
Highest HOPD Penetration							
Idaho		23.4%	46.6%	76.6%	90.3%	88.4%	
Maine		24.0%	53.0%	80.0%	92.6%	88.1%	
Delaware		35.0%	54.0%	82.0%	91.1%	87.9%	
New Hampshire		11.6%	44.7%	67.3%	87.1%	84.4%	
Lowest HOPD Penetration							
Oklahoma	2.0%	5.0%	23.0%	22.0%	45.1%	57.5%	
New York	3.0%	9.0%	20.0%	33.0%	49.5%	51.2%	
Massachusetts		11.0%	25.0%	36.0%	57.1%	57.1%	
West Virginia		12.4%	36.9%	57.8%	57.2%	62.3%	

Source: www.dexur.com; 1 Includes hospitals with at least 10 cases.

EDITORIAL

Joint Preservation: Maintaining Joint Health to Prevent or Delay Joint Replacement

NANCY STIMSON
VP Clinical Analytics at Curvo

Joint preservation is an evolving field within orthopedics and rheumatology that aims to maintain the function and integrity of joints, particularly in patients with early stage joint degeneration. This approach seeks to delay or possibly avoid the need for joint replacement surgery. These techniques are most commonly considered for individuals aged 15 to 55, with exceptions dependent on the specific conditions of the patient. Advances in regenerative medicine are intended to repair and rejuvenate damaged tissues within the joint.

Joint preservation techniques offer strategies to maintain joint function and delay the progression of joint diseases including nonsurgical and surgical options that may be viewed along a continuum from least invasive to more invasive. Nonsurgical interventions are typically the initial treatment of milder joint conditions. For patients with more pronounced joint issues but without substantial cartilage loss, various surgical techniques may be considered. Many techniques are minimally invasive, leading to shorter recovery times and reduced postoperative discomfort.

Nonsurgical Interventions

Lifestyle Modifications

Weight Management: Reducing body weight can alleviate stress on weight bearing joints, such as the knees and hips, potentially slowing the progression of joint damage.

Exercise: Low impact activities like swimming or cycling strengthen muscles surrounding the joint, improve flexibility, and support overall joint function.

Physical Therapy

Strengthening Exercises: Targeted exercises help fortify muscles that support the joint, reducing the burden on the joint itself.

Range of Motion Exercises: These exercises maintain or improve joint flexibility, which is crucial for maintaining joint health.

Manual Therapy: Physical therapists use specific techniques to enhance joint function and alleviate pain.

Medications

Pain Relievers: Nonsteroidal antiinflammatory drugs (NSAIDs) or acetaminophen can manage pain and inflammation associated with joint conditions.

Disease Modifying Agents: For inflammatory conditions like rheumatoid arthritis, medications that alter the disease course may be utilized.

Injections

Corticosteroid Injections: Injection of steroids into joint to provide temporary relief from inflammation and pain.

Hyaluronic Acid Injections: Injection of hyaluronic acid (lubricating/hydrating substance) to improve joint lubrication and cushioning.

Amniotic Fluid Injections: Injection of amniotic fluid to deliver stem cells to promote healing in the joint and provide cushioning.

Platelet Rich Plasma (PRP): Injection of a concentration of platelets derived from the patient's own blood into the joint to enhance healing.

Orthotic Devices

Braces and Supports: These devices stabilize and support the joint, potentially reducing pain and preventing further damage.

Surgical Interventions

Arthroscopy

The inspection and treatment of joint problems. It may involve cleaning out damaged tissue or repairing ligaments.

Osteotomy

Realignment of bones to reduce stress on the joint, potentially alleviating pain and improving function.

Autologous Chondrocyte Implantation (ACI)

Reimplanting previously cultured cartilage cells into the joint to promote cartilage repair.

Osteochondral Autograft Transfer System (OATS)

Replacement of damaged cartilage with healthy cartilage taken from another part of the patient's own body.

Microfracture

Creation of small fractures in the bone beneath the cartilage to stimulate the growth of new cartilage.

Drilling

Creation of small holes in the bone to stimulate cartilage repair and encourage new cartilage growth.

Abrasion Arthroplasty

Removal of damaged cartilage through abrasion to promote the growth of new, healthier cartilage.

From lifestyle changes and physical therapy to advanced surgical and regenerative methods, these approaches provide valuable options for individuals experiencing early stage joint problems. As there is no cure for more advanced stages of osteoarthritis with substantial or complete cartilage loss, joint replacement remains the gold standard in the treatment of suitable candidates. Fortunately patients are the winners as any advances in materials, sizing/shaping of implants and more precise insertion techniques are incorporated into the design of the implants.

As technology and medical knowledge continue to advance, joint preservation will likely become an even more effective and accessible solution for maintaining joint health and enhancing quality of life.

The Worldwide Hip and Knee Implant Market

The world-wide (WW) hip and knee implant market grew 7.2% between 2022 and 2023 to $18.5 billion, according to data compiled by ORTHOWORLD, of Chagrin Falls, Ohio. US sales accounted for about 64% of the 2023 sales according to ORTHOWORLD. The sales increase in 2023 was the highest in the past decade next to the COVID rebound in 2021. ORTHOWORLD estimates that US hip and knee sales grew 8.6% vs. 4.7% for the rest of the world.

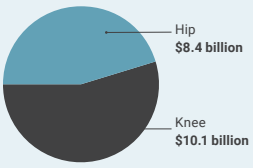
All major manufacturers reported sales growth on an as-reported basis for 2023 with Stryker exceeding the market growth rate, Zimmer Biomet growing at market and DePuy Synthes and Smith+Nephew lagging behind the overall market. The "Other" manufacturers grew 6.1% between 2022 and 2023 and accounted for more than 27% of the market. The largest hip and knee implant manufacturers in 2023 were Zimmer Biomet maintaining a 27.1% share, followed by Stryker with 20.7%, DePuy Synthes with 16.3%, and Smith and Nephew with 8.4%.

The same four major manufacturers lead in both hips and knees. DePuy Synthes has a stronger position in Hips and Zimmer Biomet, Stryker and Smith+Nephew have greater market share in Knees. "Other" manufacturers include Medacta, Aesculap, Enovis, MicroPort, Kyocera... Zimmer Biomet led both the knee and the hip market with 30.1% and 23.5% share in these respective markets. Stryker had the largest share gains in both hips and knees with 22.5% market share in knees and 18.4% in hips. DePuy Synthes lost share in both hips and knees and ranked number two and three in these respective markets, Smith & Nephew also lost share in both hips and knees and was the number four market share leader in both.

WW Hip and Knee Implant Markets and Shares, 2022-2023

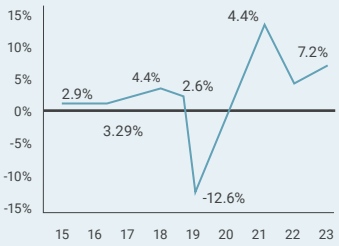
Total WW 2023 Hip/Knee Sales **$17.2 billion**
Total WW 2023 Hip/Knee Sales **$18.5 billion**
2023-2023 Increase **7.2%**

2023 WORLDWIDE SALES DISTRIBUTION



Source: ORTHOWORLD

PERCENT SALES CHANGE US & WW HIP AND KNEE IMPLANTS



Source: Orthopedic Network News, 2006-2017
Note: 2012-2016 is US Sales change, 2016-2023 is WW sales change

HIP AND KNEE IMPLANTS

Company	Sales 2022	($mill) 2023	WW Growth	2022 Share	2023 Share	Share Change
Zimmer Biomet	$4,673.2	$5,005.7	7.1%	27.1%	27.1%	0.0%
Stryker	$3,410.2	$3,817.1	11.9%	19.8%	20.7%	0.9%
DePuy Synthes	$2,873.5	$3,016.2	5.0%	16.7%	16.3%	-0.04%
Smith+Nephew	$1,490.2	$1,549.9	4.0%	8.6%	8.4%	-0.02%
Other	$4,785.3	$5,077.6	6.1%	27.8%	27.5%	-0.3%
Market Total	$17,232.4	$18,466.6	7.2%	100.0%	100.0%	

HIP IMPLANTS

Company	Sales 2022	($mill) 2023	WW Growth	2022 Share	2023 Share	Share Change
Zimmer Biomet	$1,894.9	$1,967.2	3.8%	23.8%	23.5%	-0.3%
DePuy Synthes	$1,514.5	$1,560.2	3.0%	19.0%	18.6%	-0.4%
Stryker	$1,413.1	$1,543.6	9.2%	17.7%	18.4%	0.7%
Smith+Nephew	$587.0	$603.0	2.7%	7.4%	7.2%	-0.2%
Other	$2,558.5	$2,695.1	5.3%	32.1%	32.2%	0.1%
Market Total	$7,968.0	$8,369.0	5.0%	100.0%	100.0%	

KNEE IMPLANTS

Company	Sales 2022	($mill) 2023	WW Growth	2022 Share	2023 Share	Share Change
Zimmer Biomet	$2,778.3	$3,038.5	9.4%	30.0%	30.1%	0.1%
Stryker	$1,997.0	$2,273.6	13.8%	21.6%	22.5%	.09%
DePuy Synthes	$1,359.0	$1,456.0	7.1%	14.7%	14.4%	-0.3%
Smith+Nephew	$903.2	$947.0	4.8%	9.7%	9.4%	-0.03%
Other	$2,226.8	$2,382.5	7.0%	24.0%	23.6%	-0.4%
Market Total	$9,264.4	$10,097.6	9.0%	100.0%	100.0%	

Source: Other includes approximately 150 companies for the hip and knee market including Aesculap, Medacta, Microport Orthopedics, ConforMIS, Exactech, DJO, Waldemar Link, Amplitude, Mathys, Corin, Kyocera, and Lima. Hip and Knee implants include implants, instruments and surgical assistance systems, e.g. robotics and navigation, to replace or revise failed hip and knee joints.
Source: ORTHOWORLD, Inc.

Curvo Research Network (CRN) further reviewed some of the major brands of the leading manufacturers of hip and knee implants—Zimmer Biomet, Stryker, DePuy Synthes, and Smith & Nephew from the CRN, a group of several hundred hospitals that submit data to CRN or Curvo Labs.

For convenience sake, the sales of total, partial, and revision hips have been combined for hip implants, and total, unicondylar, and revision knees for knee implants.

For the leading manufacturer of hip implants in the CRN, Zimmer Biomet, the Arcos, Taperloc and Avenir accounted for 65% of their hip implant systems, with the Avenir showing the greatest growth. For Stryker, the Accolade, Restoration, and Insignia were the leading three brands which accounted for more than 90% of their hip sales. The more recently launched Insignia system cannibalized share from Accolade. DePuy Synthes hip sales were led by Actis, Corail, and Summit which together accounted for about 88% of their hip sales in 2023. Smith & Nephew's Polarstem, Redapt, and Anthology systems accounted for about 75%.

The top 4 manufacturers of knee implants had a similar amount of brand concentration. Zimmer Biomet's Persona, Vanguard and NexGen accounted for 88% of their knee sales, while Stryker's Triathlon for 92% of their sales. DePuy Synthes' Attune, Sigma, and LPS accounted for 95% of theirs, and Smith & Nephew's Legion, Journey and Genesis had 100% of their US sales.

CRN identified the "fastest growing hip and knee implant companies" based on sales changes at hospitals that reported sales of hip implants in both 2022 and 2023. Because most of these companies' sales are relatively low, CRN reports a range of percentage increases rather than an absolute number to eliminate the distortion accompanying small numbers. Based on the analysis, the fastest growing hip implant companies were Enovis, Kyocera, Onkos Surgical, OsteoRemedies, Waldemar Link and Corin. All reported at least double-digit sales growth, while some reported over 100% sales growth in the selected hospitals. The fastest growing knee implant companies included Enovis, Ortho Development, Onkos Surgical, OsteoRemedies, Waldemar Link, Corin and MicroPort. It should be emphasized that the actual sales at these companies is not public information, so it is very possible that they may not see the sales increases reported here.

Distribution of Sales, Selected Hip and Knee Implants 2022-2023

HIP IMPLANTS Mfg	Top 3 Major Brands of Hips	2022 CRN $ Mix	2023 CRN $ Mix	Change 22-23
Zimmer Biomet	Taperloc	35%	25%	-10%
	Arcos	10%	11%	1%
	Avenir	23%	30%	7%
	Other	32%	35%	3%
		100%	100%	
Stryker	Accolade	71%	61%	-10%
	Restoration	9%	13%	4%
	Insignia	7%	17%	10%
	Other	12%	9%	-3%
		100%	100%	
DePuy Synthes	Actis	50%	58%	8%
	Corail	19%	10%	-9%
	Summit	21%	20%	-1%
	Other	10%	12%	2%
		100%	100%	
Smith & Nephew	Polarstem	38%	28%	-10%
	Redapt	14%	28%	14%
	Anthology	25%	19%	-6%
	Other	22%	25%	3%
		100%	100%	

KNEE IMPLANTS Mfg	Top 3 Major Brands of Hips	2022 CRN $ Mix	2023 CRN $ Mix	Change 22-23
Zimmer Biomet	Persona	66%	65%	-1%
	Vanguard	18%	19%	1%
	NexGen	5%	4%	-1%
	Other	11%	12%	1%
		100%	100%	
Stryker	Triathlon	92%	92%	0%
	Restoris	5%	3%	-2%
	GMRS	2%	3%	1%
	Other	2%	2%	0%
		100%	100%	
DePuy Synthes	Attune	78%	79%	1%
	Sigma	11%	7%	-4%
	LPS	7%	9%	2%
	Other	4%	5%	1%
		100%	100%	
Smith & Nephew	Legion	51%	64%	13%
	Journey	44%	30%	-14%
	Genesis	5%	6%	1%
	Other	0%	0%	0%
		100%	100%	

Fastest Growing Hip and Knee Implant Companies (US) 2022-2023

FASTEST GROWING HIP IMPLANT MANUFACTURERS

Manufacturer	2022-2023 Increase
Enovis	> 100%
Kyocera	> 70%
Onkos Surgical	> 70%
OsteoRemedies	> 40%
Waldemar Link	> 40%
Corin	> 30%
MicroPort	> 10%

FASTEST GROWING KNEE IMPLANT MANUFACTURERS

Manufacturer	2022-2023 Increase
Enovis	> 100%
Ortho Development	> 100%
Onkos Surgical	> 50%
OsteoRemedies	> 40%
Waldemar Link	> 40%
Corin	> 30%
MicroPort	> 10%

The Publicly Traded Companies

The largest US hip and knee implant manufacturers are publicly traded. As public companies, their financial performance is subject to quarterly and annual reporting through the Securities and Exchange Commission (SEC). Theoretically, one can impute how a company spends its money on products from their filings, however that is often challenging because of mergers and acquisitions or having publicly traded orthopedic companies buried inside larger ones. For example, DePuy Synthes is a reporting unit of Johnson & Johnson where the expenses of orthopedic products are not detailed.

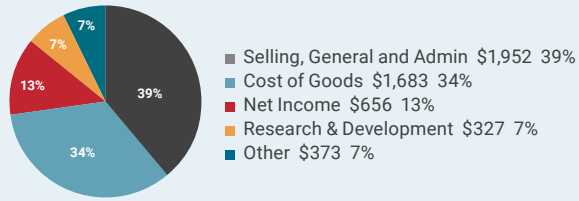
The table below examines the annual reports from Zimmer Biomet, Stryker, Johnson & Johnson, Smith & Nephew.

Company annual reports separate expenses into categories of cost of goods sold, selling/general/administrative expenses, research and development, taxes, and net income. Cost of goods sold relates to implant and instrument material and manufacturing cost and is measured as a percentage of sales. Royalty payments to surgeon consultants may be counted in R&D or in cost of goods depending on the terms of the agreement and company policy.

Based on the overall average percentages of expenses, the largest component of these companies' expenses was selling, general, and administrative expenses, which averaged 39.0% in 2023, unchanged from 2022. Research and development averaged 6.5% of sales in 2023, down from 7.1% in 2022, and the cost to manufacturer (cost of goods) was the second largest category of expenses at 33.7% for the group, up slightly from 33.6% in 2022.

Components of an Orthopedic Implant

COMPONENTS OF A $5,000 IMPLANT



Source: Components allocated based on ZB, Stryker, J&J and S&N 2023 average.

All of the companies reported increases in net income; Stryker reported net income of more than $3.1 billion, up from approximately $2.3 billion in 2022; Zimmer Biomet reported net income of $1.0 billion, and Smith & Nephew reported income of $263 million. Sales growth was mixed, with Stryker reporting growth of 10.5%, Zimmer Biomet 6.6%, Smith & Nephew 4.8% and DePuy Synthes 4.1%.

The world-wide sales of hip and knee implants were obtained from company filings and compared to their overall orthopedic portfolio. A high percentage indicates the company is dependent on hip and knee replacements to drive their sales and growth. The highest percentage was reported for Zimmer Biomet with 67.7% of its orthopedics sales derived from hip and knee replacements. Stryker hip and knee sales represented 44.1% of the company's orthopedics sales, but 18.6% of overall sales. DePuy Synthes and Smith & Nephew reported 33.7% and 27.7% respectively.

Comparison of 2022-2023 Key Financial Statistics, Publicly Traded Orthopedic Implant Companies

	2023 WW	Cost of Goods		Research and Development		Selling, General Admin		Net Income		WW Hip and Knee		WW Sales Change
Manufacturer	**$ (mills)[1]**	**$ (mills)**	**%**	**$ (mills)**	**%**	**$ (mills)**	**%**	**$ (mills)**	**%**	**$ Sales**	**% WW Sls**	**22-23**
Stryker	$20,498	$7,440	36.3%	$1,388	6.8%	$7,129	34.8%	$3,165	15.4%	$3,817	44.1%	
Stryker Ortho	$8,662											10.5%
All Johnson & Johnson	$85,159	$26,553	31.2%	$15,085	17.7%	$21,512	25.3%	$35,153	41.3%			
Orthopedics	$8,942									$3,016	33.7%	4.1%
Zimmer Biomet	$7,394	$2,084	28.2%	$459	6.2%	$2,869	38.8%	$1,024	13.8%	$5,005	67.7%	6.6%
Smith & Nephew	$5,549	$1,730	29.5%	$339	6.6%	$3,055	55.1%	$263	4.3%			
Orthopedics	$2,214									$1,539	27.7%	4.8%
Average			33.7%		6.5%		39.0%		13.3%		31.0%	6.5%

Hospital Resources and Implant Cost Management — A 2024 Update

The average cost of a hip and knee implant for CRN hospitals in 2023 increased 2% to $5,139. This estimate is based on data obtained from a group of 303 hospitals that submitted data in either 2022 or 2023. Note that the implant costs per case include not only implants, but also bone cement, bone grafts and substitutes, instruments, robotics (usage fees/disposables), soft tissue balancing, loaner fees, and other supply costs associated with the surgeries. These represent 5.5% of the total spend, down from 5.9% last year.

The overall ASP for all hip procedures increased 1% to $5,075 while the overall knee implant costs increased 2% to $5,186. The largest increases were reported for partial knee and hip, up 6% and 5% respectively. Primary knee and total hip were flat and revision knee and hip increased 3% and decreased 7% respectively.

Procedure mix changed in 2023, with revision hip and knee growing proportionally. Total hip, primary knee, and partial hip and knee, all declined proportionally.

Total Hips

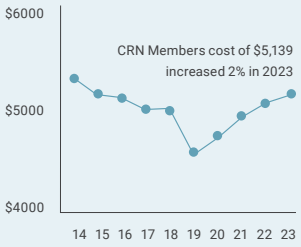
The trends in total hips that began more than a decade ago are now fairly settled. Hard-on-hard surfaces, which include metal on metal hips or ceramic on ceramic hips, have disappeared. Porous stems and ceramic heads with poly liners now dominate. In addition, mobile bearing hips are showing up more because of a reclassification of some devices into a new category.

Hard-on-hard hips disappeared in the 2023 CRN, down from as much as 43% in 2007. Ceramic heads with coated hip stems and poly liners accounted for 72% of the cases in 2023, while metal heads with coated hip stems accounted for 14% of the cases. Coated hip stems have increased from 40% of the stems in 1999 to 93% in 2023, while the cemented hip stems declined from 54% of the stems in total hips in 1999 to 4% in 2023.

The mobile bearing hip average selling price (ASP) increased 5.7% between 2022 and 2023 to $6,632, while the constructs which used coated hip stem and ceramic head decreased 3.8%, and the coated hip stem with a metal head increased 1.3%.

Average Cost of Implant Components by Procedure

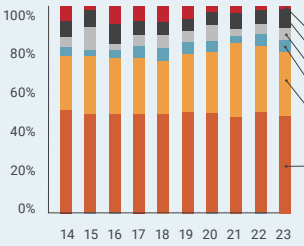
IMPLANT COST/PROCEDURE



	2022	2023	Chg
Overall	$5,063	$5,139	2%
Total hip	$5,224	$5,212	0%
Primary knee	$4,280	$4,278	0%
Partial hip	$3,131	$3,301	5%
Partial knee	$4,204	$4,437	6%
Revision hip	$5,905	$6,066	3%
Revision knee	$10,989	$10,171	-7%
Overall Hips	$5,015	$5,075	1%
Overall Knees	$5,099	$5,186	2%
Overall Hip + Knee	$5,063	$5,139	2%

Source: CRN

CRN Market Share by Procedure 2014-2023

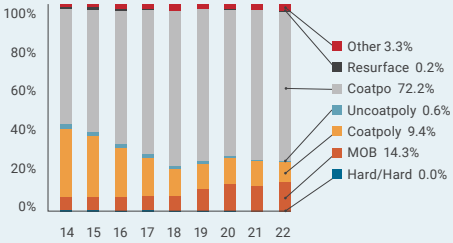


	2022	2023	Chg
Partial knee	2.0%	1.8%	-0.2%
Revision knee	7.0%	8.8%	1.8%
Revision hip	5.0%	6.0%	1.0%
Partial hip	6.0%	5.7%	-0.3%
Total Hip	32.3%	30.8%	-1.5%
Total Knee	47.8%	46.9%	-0.9%
	100.0%	100.0%	

Source: CRN

Trends in Total Hip Constructs, 2014-2023

PERCENT OF CASES BY CONSTRUCT TYPE

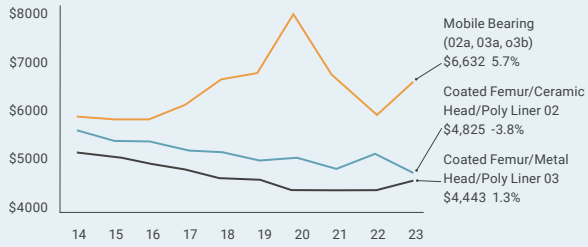


Summary	1999	2010	2021	2022	2023
Coated Hip System - Cons 02,02a,03,03a	40%	92%	96%	94%	93%
Uncoated Hip Systems - Cons 04,05	54%	7%	4%	4%	4%

Source: CRN. Includes shares of procedures for selected IDNs.

Trends in ASPs for Total Hip Constructs, 2014-2023

AVERAGE SELLING PRICE BY CONSTRUCT TYPE



Source: CRN Cases for selected IDNs.

Component Usage and Trends in Hip Replacements

80% of hips stems were coated in the CRN compared to 12% uncoated, 8% long or revision stems, and 1% other stems. Revision hip stems averaged $7,932, up 4.4% from 2022, coated hip stems averaged $1,996, up 4.7% from 2022, and uncoated hip stems increased to 5.2% to $1,346. Modular revision stems, such as Zimmer Biomet's Arcos which use multiple components to create a revision stem, are included in the calculation of revision hip stem prices.

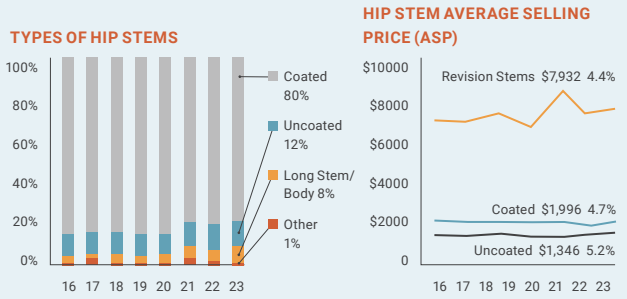
Ceramic heads accounted for 70% of the femoral heads in the 2023 CRN, down from 75% in 2022. The ASP for both ceramic and metal heads increased 2% over the prior year to $978 and $530 respectively.

Femoral heads were segmented into 32mm and less, 36mm, and greater than 36mm sizes. In 2023, 38% of the ceramic and metal femoral heads were 32mm or less, 53% were 36mm, and 10% were larger than 36mm. Until hardened acetabular liners appeared on the market in 2002, femoral heads were available in sizes of 22-, 26-, 28-, and 32-millimeter diameters. Larger heads were more "anatomic" but had the disadvantage of providing a greater surface area with the acetabular liner from which polyethylene wear debris could originate. This was thought to be one of the main causes of femoral osteolysis. When hard polyethylenes were introduced in 2002, this encouraged the use of larger femoral heads to reduce dislocations. By 2014, most femoral heads were 36mm or larger, according to historical data from the CRN.

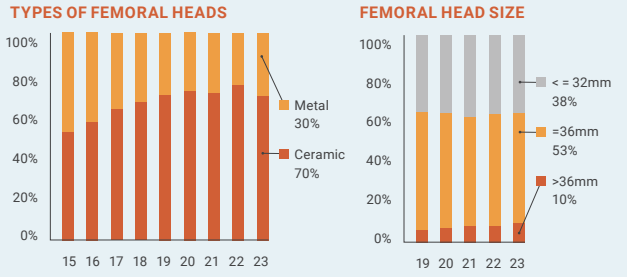
Acetabular liners have been the most significant contributor to changes in orthopedic practice with "hard" surfaces and improved polyethylenes. In 2023, cross-linked poly liners accounted for about 72% of liners sold, the "conventional polyethylene" about 5% of liners, and the anti-oxidant enhanced liners accounted for 22% of the liners. Anti-oxidant enhanced polyethylene, frequently treated with Vitamin E, has been shown to have improved wear-resistance and improved longevity. The average prices of these liners represent the pricing differential for "newer" technology: the cross-linked poly had an ASP of $927, and the antioxidant poly cost $1,156 in the 2023 CRN.

Between 2021 and 2023, 2.5% to 5.5% of the total hips in the CRN included femoral and acetabular components from different manufacturers. 2.5% of the cases in 2023 included "mix-match" components. 40% were Zimmer Biomet G7 shell and DePuy Synthes ARTICUL/EZE BIOLOX delta Heads. This is important because it makes the contracting for total hips difficult since a "cap" price must be split between two vendors. There also may be clinical compatibility issues in a total hip that employs designs from two companies.

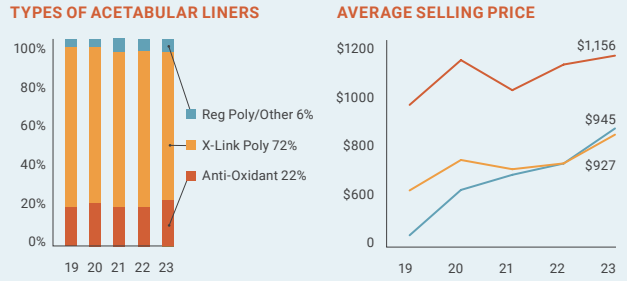
Usage and ASPs of Femoral Stems, 2016-2023



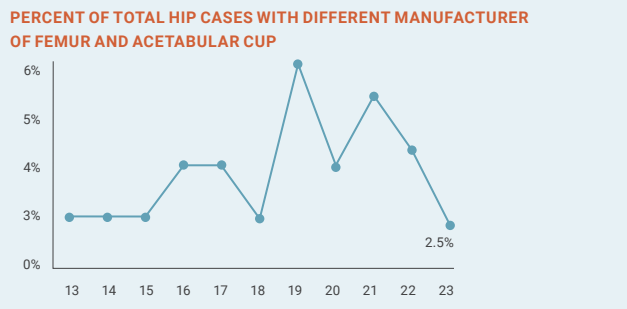
Usage, Size and ASPs of Femoral Heads, 2015-2023



Materials and ASPs of Acetabular Liners, 2019-2023



Total Hip, "Mix-n-Match" Femurs and Cups



~ 40% were Zimmer Biomet G7 shell and DePuy Synthes ARTICUL/EZE BIOLOX delta Heads
Source: Curvo Research Network (CRN). Note: Nearly 2/3 of the mix-n-match were DePuy Synthes' femoral components with Stryker Trident II cups

Mobile-bearing cups include two-piece cups with a normal cup and a mobile bearing liner and three-piece cups with a cup, mobile bearing liner, and poly liner. There has been an increase in the use of three-piece vs. two-piece mobile bearing cups between 2015 and 2023. In 2015, 35% of the cases used three-piece mobile bearing cups, which increased to 92% of the cases in 2023. The ASP of cases with two-piece cups was $4,949 in the 2023 CRN compared to $6,772 for cases with the three-piece cup.

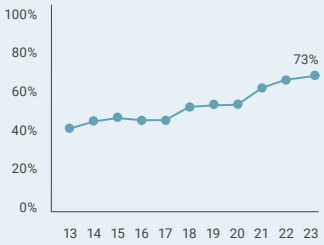
The 2023 CRN indicates an increase in the number of "ultraporous" coatings of acetabular shells, i.e. those with brand names such as Gription (DePuy), Tritanium (Stryker), OsseoTi and Trabecular Metal (Zimmer Biomet), and p² (Enovis). The percentage of shells with the ultraporous coating increased from practically nothing in 2000, to 73% in 2023. In 2023, the average selling price of an ultraporous shell was $1,359 compared to $1,007 for a non-ultraporous shell.

The design of the cups can also drive costs. In response to the need to improve fixation of the cup, manufacturers have provided holes in the cups to screw them into the pelvis. Because the way of counting holes is inconsistent across manufacturers, CRN has grouped them into Solid, 1-2 hole, 3-4 hole, and over 4 hole. There has been a marked increase in the number of holes in cups: in 2013, 65% of the cups were 3 or more holes, and by 2023, 94% of the cups had 3 or more holes.

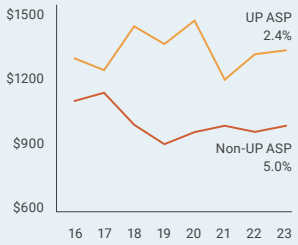
In general, more holes provide greater flexibility for placing screws into solid bone in the acetabulum. However, more holes generally increase the shell cost, and the cost of screws (about $74 each) and the cost of plugs to fill unused holes (about $73 each). This will increase the overall cost of implanting the shell into the acetabulum. According to the CRN, the number of screws used in shells has stayed relatively constant at about 0.7 – 0.9 screws per total hip case between 2014 and 2023. However, in 2023, 94% of the acetabular shells had at least one hole and 54% of the total hip cases had no screws, indicating that there are many cups implanted with holes that had no screws. A portion of the cost differential is not related to the number of holes, but rather to the material. More than 80% of the > 4-hole cups are ultra-porous vs. less than 60% of the < 4-hole.

Materials for Acestabular Shells, 2013-2023

ACETABULEAR SHELL (PRIMARY ONLY) ULTRAPOROUS GROWTH

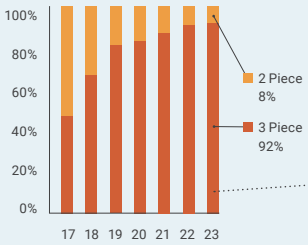


ASPS OF ACETABULAR SHELL (PRIMARY ONLY) MATERIALS

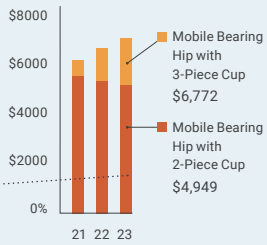


Mobile Bearing Cups, 2015-2023

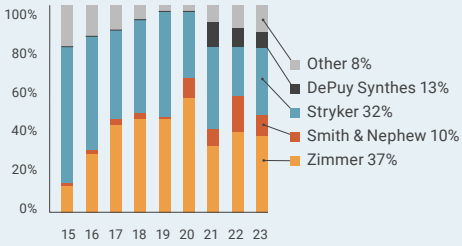
TYPES OF MOBILE BEARING CUPS



AVERAGE CASE COST BY MOBILE BEARING CUP TYPE

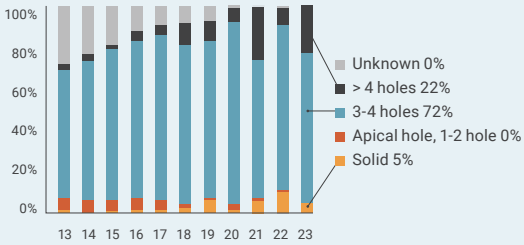


MARKET SHARE (DOLLARS) OF MOBILE BEARING CUPS

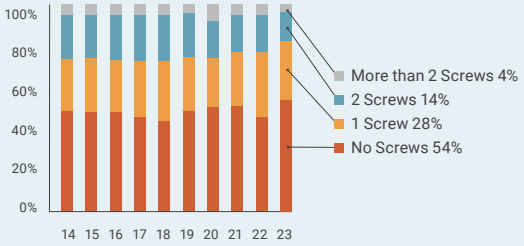


Trends in Number of Hole in Acetabular Shells, Screws, 2013-2023

TRENDS IN HOLES ACETABULAR SHELLS



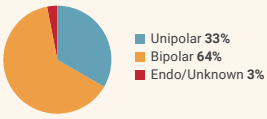
TRENDS IN ACETABULAR SCREWS USED IN ACETABULAR SHELLS



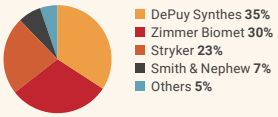
Source: CRN. Includes shares of procedures for selected IDNs.

2024 U.S. Hip Implant Price Comparison
Market Share 2023 CRN

Constructs of Partial Hips

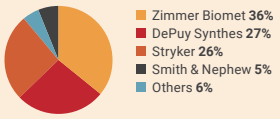


Top 5 Unipolar Constructs (Constructs 08, 08a)



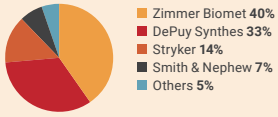
Summit	**DPY**
Stem	1570-03-100
Head	1363-44-000
Tapered Spacer	1363-08-000
2023 ASP	**$2,221**
Echo FX	**ZBH**
Stem	12-151309
Head	12-139020
Taper Insert	139247
2023 ASP	**$1,596**
Accolade C	**SYK**
Stem	6058-0435D
Head	6942-5-046
Taper Sleeve	6942-6-065
2023 ASP	**$2,920**
Accolade II	**SYK**
Stem	6721-0635
Head	6942-5-050
Taper Insert	6942-6-065
2023 ASP	**$2,787**
Summit Basic	**DPY**
Stem	1570-06-090
Head	1363-46-000
Spacer	1363-10-000
2023 ASP	**$1,497**

Top 4 BiPolar Partial Hips (Constructs 07, 07a)



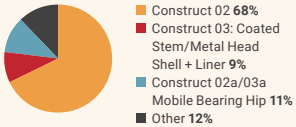
ASummit, ARTICUL/EZE head	**DPY**
Stem	1570-03-110
Head	1365-11-000
Bipolar	1035-45-000
2023 ASP	**$2,595**
Accolade C, Lfit V40 head, UHR bipolar cup	**SYK**
Stem	6058-0537D
Head	6260-9-128
Bipolar	UH1-44-28
2023 ASP	**$2,679**
Accolade II, Lfit V40 head, UHR bipolar cup	**SYK**
Stem	6721-0535
Head	6260-9-128
Bipolar	UH1-46-28
2023 ASP	**$3,313**
Avenir Complete	**ZBH**
Stem	574101040
Head	802202802
Bipolar	00-5001-044-00
2023 ASP	**$3,132**

Top 3 Mobile Bearing Hip Constructs (Constructs 02a, 03a, 03b)

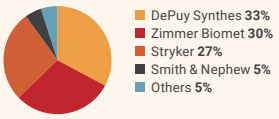


Arcos Modular Revision stem w/G7	**ZBH**
Stem	11-301300
Head	650-1055
Shell	110010244
X-Link Poly Liner	110031012
CoCr Liner	110024464
2023 ASP	**$11,633**
Accolade II stem w/Restoration MDM	**SYK**
Stem	6721-0435
Head	6570-0-128
Shell	702-04-52E
Poly Liner	7236-2-848
CoCr Liner	626-00-42E
2023 ASP	**$5,781**
Actis DuoFix stem w/Trident II	**DPY**
Stem	6276-1-023
Head	6570-0-228
Shell	1217-32-054
Poly Liner	122128047
CoCr Liner	1218-54-047
2023 ASP	**$8,653**

Constructs of Total Hips

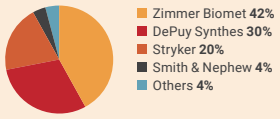


Top 7 Coated Stem, Ceramic on Poly Constructs (Construct 02)



Actis stem, 36mm head, Pinnacle shell, AltrX liner	**DPY**
Stem	1010-11-060
Head	1365-36-710
Shell	1217-32-052
Liner	1221-36-052
2023 ASP	**$4,726**
Accolade II 36mm metal head, Trident shell, X3 liner	**SYK**
Stem	6721-0435
Head	6570-0-136
Shell	702-04-52E
Liner	723-00-36E
2023 ASP	**$4,420**
Avenir stem w/G7 shell/liner	**ZBH**
Stem	574201040
Head	00-8775-036-02
Shell	110010243
Liner	30103604
2023 ASP	**$5,704**
Insignia stem, Trident II shell, Trident X3 liner	**SYK**
Stem	7000-6605
Head	6570-0-136
Shell	702-04-52E
Liner	723-00-36E
2023 ASP	**$4,794**
TaperLoc 133 HO stem, G7 shell and liner	**ZBH**
Stem	51-104120
Head	650-1057
Shell	110010246
Liner	30103606
2023 ASP	**$5,277**
Corail stem, Pinnacle shell w/Gription, AltrX Liner	**DPY**
Stem	3L92501
Head	1365-36-710
Shell	1217-32-052
Liner	1221-36-452
2023 ASP	**$4,876**
Polarstem stem, R3 shell and liner	**SNN**
Stem	75018403
Head	7134-3600
Shell	7133-5552
Liner	7133-2752
2023 ASP	**$4,930**

Top 5 Coated Stem, Metal on Poly Constructs (Construct 03)



Accolade II 36mm metal head, Trident shell, X3 liner	**SYK**
Stem	6721-0635
Head	6260-9-136
Shell	702-04-50D
Liner	723-00-36E
2023 ASP	**$4,015**
Actis DuoFix stem, 36mm head, Pinnacle shell, AltrX liner	**DPY**
Stem	1010-11-070
Head	1365-50-000
Shell	1217-32-054
Liner	1221-36-052
2023 ASP	**$4,217**
M/L Taper stem,Continuum shell, Trilogy Longevity liner	**DPY**
Stem	00-7711-009-10
Head	802203602
Shell	00-8757-052-01
Liner	00-8752-010-36
2023 ASP	**$4,259**
Taperloc 133 HO stem G7 shell and liner	**ZBH**
Stem	51-107130
Head	11-363661
Shell	010000664
Liner	30103606
2023 ASP	**$4,705**
Corail stem, Pinnacle Gription shell, AltrX liner	**DPY**
Stem	3L92502
Head	1365-50-000
Shell	1217-32-052
Liner	1221-36-052
2023 ASP	**$3,830**

2024 U.S. Knee Implant Price Comparison Market Share 2023 CRN

The constructs and components are those reported through the CRN (Curvo Research Network), 2023 edition.

The "ASP" (average selling price) is the average price for each of the components found in 2023 Curvo Research Network. The ASPs were obtained from the 2023 CRN.

Since there are literally thousands of combinations of parts for each of the constructs, the parts selected for each of the constructs shown here are the most frequently used ones for each manufacturer/construct combination in the CRN. As such, the components selected may not make sense clinically.

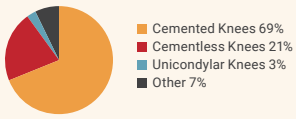
The classification of hip and knee implant components uses the GIC® classification and the constructs are the orthopedic constructs® developed by Orthopedic Network News.

For the most recent pricing and construct information, consult www.curvolabs.com.

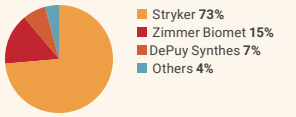
Abbreviations

ZBH: Zimmer Biomet
DPY: DePuy Synthes
SNN: Smith & Nephew
SYK: Stryker
MED: Medacta

Constructs of Primary Knees



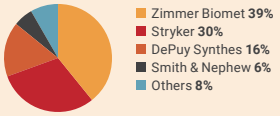
Top 2 Cementless Knee Constructs (Construct 23)



Triathlon	**SYK**
Femur	5517-F-401
Tibia	5536-B-400
Insert	5531-G-409-E
Patella	5552-L-320
2023 ASP	**$4,172**

Attune	**DPY**
Femur	150401107
Tibia	150621007
Insert	152020605
Patella	151810035
2023 ASP	**$4,287**

Top 6 Uncoated Femur/Uncoated Tibia Constructs (Construct 24)



Triathlon PS femur, tibia, X3 insert and patella	**SYK**
Femur	5510-F-402
Tibia	5521-B-400
Insert	5531-G-409-E
Patella	5551-G-320-E
2023 ASP	**$3,564**

Persona	**ZBH**
Femur	42-5026-066-01
Tibia	42-5320-071-01
Insert	42-5221-008-10
Patella	42-5402-000-32
Stem	42-5570-001-14
2023 ASP	**$4,713**

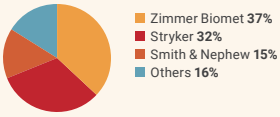
Attune PS Fixed Bearing	**DPY**
Femur	1504-10-207
Tibia	1506-70-004
Insert	1516-40-606
Patella	1518-20-038
2023 ASP	**$3,815**

Vanguard CR femur, I-Beam tibial tray	**ZBH**
Femur	183028
Tibia	141233
Insert	183640
Patella	184792
Stem	141314
2023 ASP	**$4,170**

Legion	**SNN**
Femur	7142-1275
Tibia	7142-0164
Insert	7145-3211
Patella	7142-1032
2023 ASP	**$5,586**

Journey II Oxinium, PS Hi-flex insert	**SNN**
Femur	7402-2116
Tibia	7402-2213
Insert	7402-7241
Patella	7142-1032
2023 ASP	**$4,487**

Top 4 Unicondylar Knee Constructs (Construct 26)



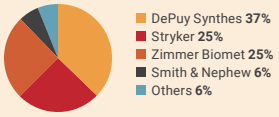
Persona	**ZBH**
Femur	42-5580-004-02
Tibia	42-5380-006-02
Insert	42-5282-006-08
2023 ASP	**$3,660**

Oxford	**ZBH**
Femur	161469
Tibia	159548
Insert	159576
2023 ASP	**$3,666**

Journey II Uni	**SNN**
Femur	71422356
Tibia	74026728
Insert	74026178
2023 ASP	**$6,059**

Constructs of Revision Knees

Top 5 Revision Knee Constructs (Construct 24a)



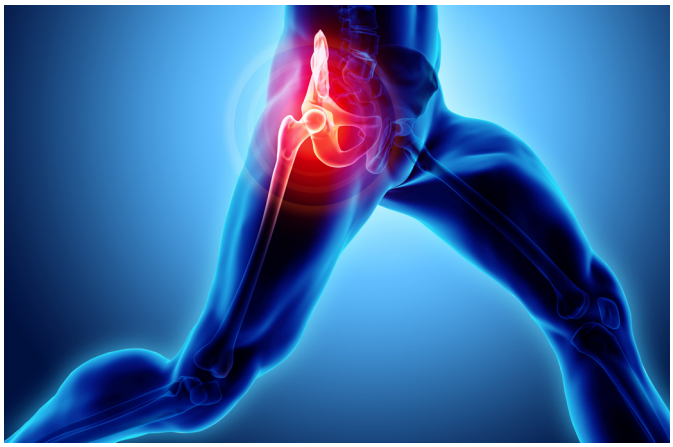
Attune Revision	**DPY**
Femur	1504-40-206
Tibia	1506-60-003
Sleeve	1511-11-202
Insert	1517-10-608
Patella	1518-20-035
Wedge	1549-06-001
Stem	1513-16-060
2023 ASP	**$17,769**

Triathalon TS	**DPY**
Femur	5512-F-402
Tibia	5521-B-300
Insert	5537-G-313-E
Patella	5551-G-350-E
Augment	5543-A-600
Stem-Fluted	5560-S-112
2023 ASP	**$12,251**

Persona	**ZBH**
Femur	42-5046-058-02
Tibia	42-5420-071-02
Cone	42-5450-005-10
Insert	42-5228-007-12
Patella	42-5402-000-32
Augment	42-5566-058-05
Stem-Fluted	42-5600-075-14
2023 ASP	**$20,569**

Legion	**SNN**
Femur	7142-1177
Tibia	7142-4014
Insert	7142-0526
Patella	7192-6225
Coupler	7142-4225
Stem	7142-4048
Wedge	7142-1664
2023 ASP	**$17,207**

Vanguard SSK	**ZBH**
Femur	185264
Tibia	185202
Insert	183880
Patella	184788
Adapter	185211
Sleeve	145024
Fluted Stem	185342
2023 ASP	**$14,708**



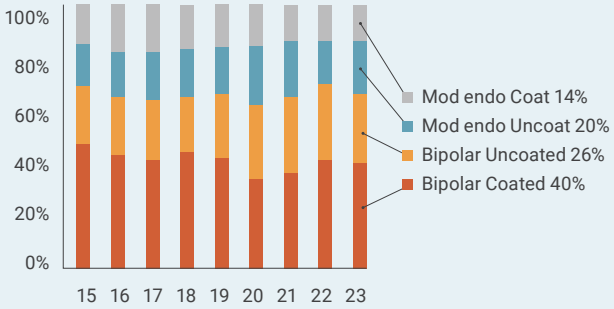
Partial Hips

Bipolar hips accounted for 66% of the cases and the remaining 34% of the partial hip cases were modular endoprostheses. The average selling price of a bipolar hip with a coated stem was $3,604 in 2023, down 1% from 2022. The bipolar hip with an uncoated stem was $3,051 in 2023, down 5% from the prior year. The weighted average of modular endoprostheses with and without coated hip stems was $3,126 in 2023, down 1% from 2022.

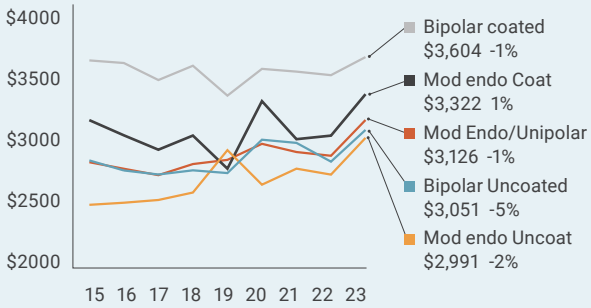
Of the individual components used in partial hips, 63% were bipolar and approximately 37% were unipolar heads. The bipolar heads averaged $644 per component in 2023, up 9% from 2022, and the unipolar heads averaged $402 in 2023, up 7% from 2022.

Trends in Partial Hip Implant Construct Types, 2015-2023

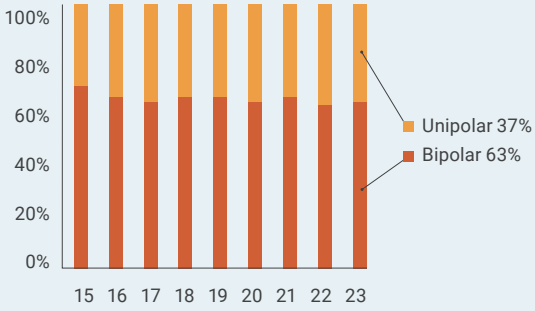
PERCENT OF CASES BY CONSTRUCT TYPE 2015-2023



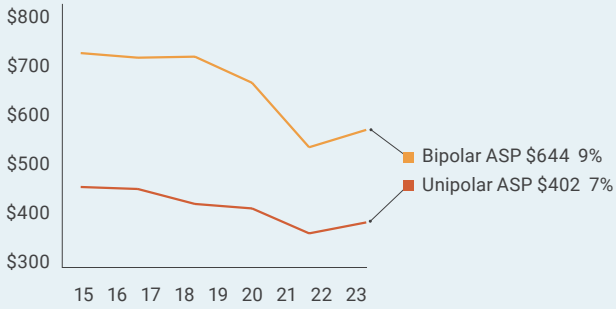
AVERAGE SELLING PRICE BY CONSTRUCT TYPE 2015-2023

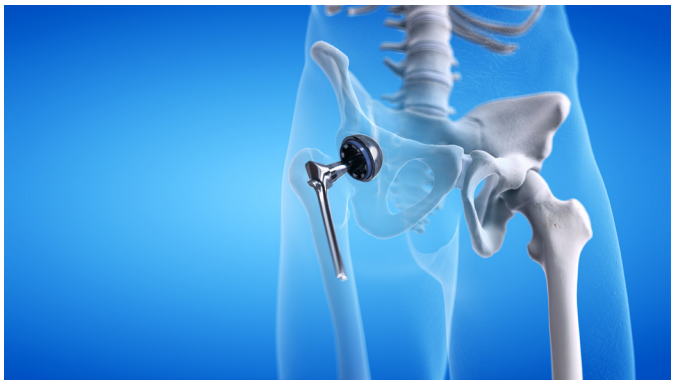


FEMORAL HEADS FOR PARTIAL HIPS



ASPS FOR PARTIAL HIP HEADS





Revision Hips

16.5% of hip procedures in the CRN in 2023 were revisions. This statistic is referred to as the "revision burden" and is comparable to the iData estimate of 10.2%.

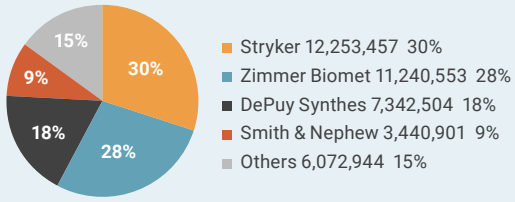
Revision hip market share in the 2023 CRN was led by Stryker with 30%, followed by Zimmer Biomet with 28%, DePuy Synthes with 18%, Smith & Nephew with 8% and "Other" with 15% of the cases. Other includes OsteoRemedies, Microport, LinkBio, Medacta, Exactech, among others. Femoral stems used in revision cases are divided by CRN into one-piece stems, separate proximal body and distal stem combinations, and temporary femurs used in two-stage revisions. Since 2003, there has been a trend away from one-piece stems which accounted for 67% of the stems in 2004 to approximately 29.5% in 2023. The percentage of temporary stems used in two-stage revisions was approximately 11% of the revision stems in 2023. The body/stem combinations accounted for 59% of the revision stems in 2023.

CRN classifies revision hips into categories based on the disruption to the bone structures. In 2023, the most frequent hip revisions were for cases with those where a pelvic disruption occurred which accounted for 41% of the cases. Revisions with disruptions to the femur accounted for 30% of the cases. In 21% of the cases, no disruption to the femur or the acetabulum exemplified by a head or liner exchange. The remaining 9% of the cases involved both the femur and the pelvis. At one extreme, revisions that involved femoral and pelvic disruptions cost CRN members an average of $13,305 and at the other extreme, components which did not interfere with the metal-bone interface cost around $4,069 in 2023.

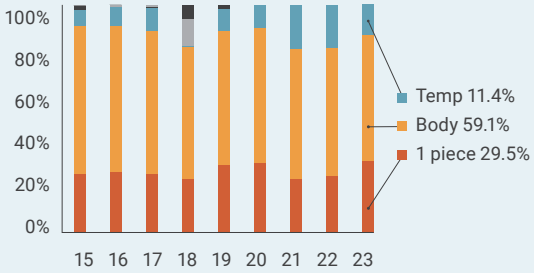
Revision Hips, 2015-2023

PERCENT OF HIPS THAT ARE REVISIONS IN THE CURVO RESEARCH NETWORK

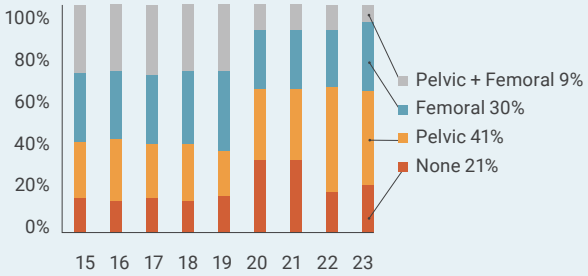
2023 MARKET SHARE OF HIP REVISIONS



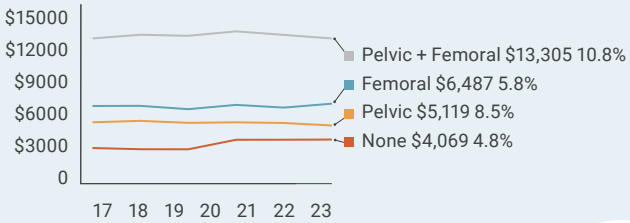
TRENDS IN HIP STEMS FOR REVISION HIPS



TYPE OF "DISRUPTION" FOR REVISION HIPS



ASPS OF REVISION HIPS



Knee Implants

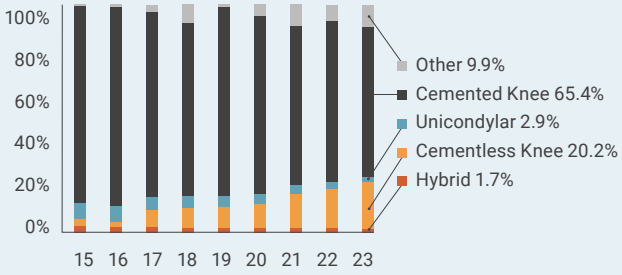
Of the different types of constructs, knee replacements have favored uncoated femur and tibial combinations ("cemented" knees") with 65% of the procedures receiving this construct in 2023. Cementless" knee systems have grown from 3.1% of the cases in 2016 to 20% in 2023. The hybrid cases, i.e., those with a coated femur and an uncoated tibia accounted for 1.7% of the procedures in 2023, and the unicondylar procedures accounted for about 2.9% of the total number of knee procedures in 2023.

The implant costs per procedure of knee implants in 2023 varied from unicondylar knees at $4,154 per procedure, to $4,327 for a coated femur/tibial ("cementless") construct.

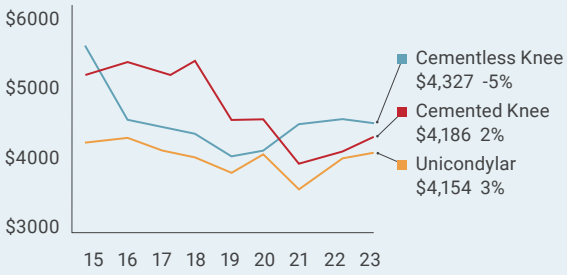
Femoral components for knee replacements in 2023 were largely uncoated (70%), followed by coated (21%), unicondylar (3%), and revision/oncology (6%). ASPs in 2023 ranged from $1,573 for an uncoated femur, $1,773 for a unicondylar femur, and $1,780 for a coated bicondylar knee femur. Revision-oncology or revision knee femurs ASPs were $6,279 in 2023

Total Knees Key Factors, 2015-2023

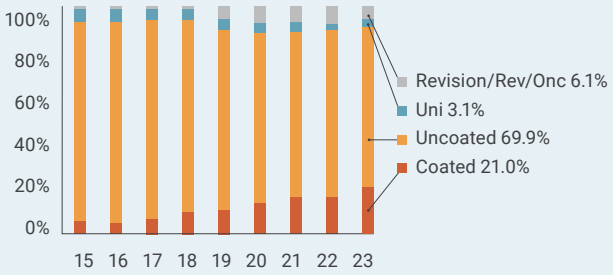
PERCENT OF CASES BY CONSTRUCT TYPES, 2015-2023



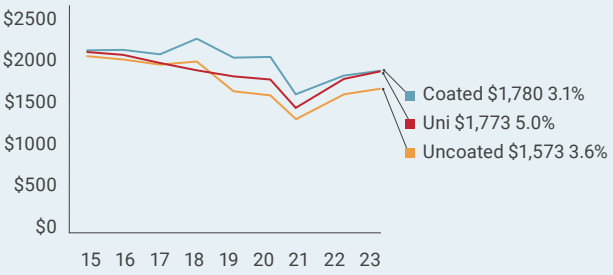
AVERAGE SELLING PRICE BY CONSTRUCT TYPE, 2015-2023



TYPES OF FEMURS



ASP OF KNEE FEMURS BY TYPE



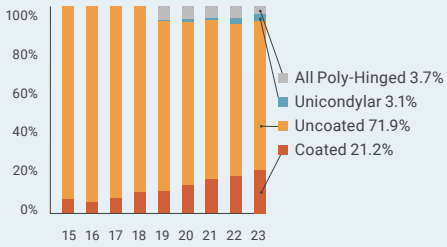
Tibial Components

Tibial components used in bicondylar knees in 2023 were largely uncoated (72%), followed by coated implants (21%), all poly tibias or hinged tibias (4%) and unicondylar tibias (3%). ASPs for coated tibias in 2023 were $1,302 (up 6.5% from 2022), and $1,078 for uncoated tibias (up 5.0%). Tibial insert ASPs increased 7.5% to $1,046. Mobile bearing inserts have declined from 12% of the inserts in 2007 to 5% in 2023. 57% of the tibial inserts had some sort of stabilization (posterior or cruciate), while 26% were cruciate retaining, and 5% were constrained. In the CRN sample, anti-oxidant tibial inserts accounted for 37% of the inserts in 2023. Anti-oxidant polys are used more frequently in knees (37%) vs. hips (22%), although the price premium for antioxidant polys in hips was greater than in knees. An anti-oxidant poly tibial insert costs $1,072 vs. $912 for the non-anti-oxidant, a $161 difference. In hips the difference was $1,156 for a nonantioxidant poly liner vs. $927 for the anti-oxidant version, a $229 premium.

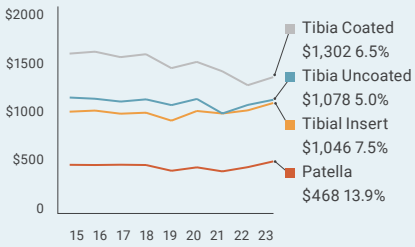
Source: CRN

Tibial Component Key Factors, 2015-2023

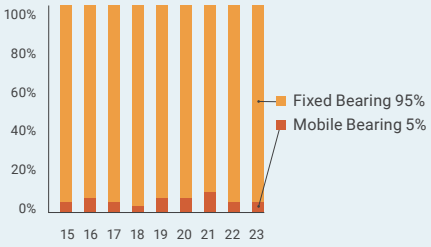
TIBIAL COMPONENTS USAGE (BICONDYLAR)



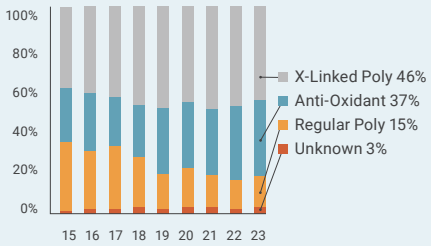
ASP OF OTHER KNEE COMPONENTS



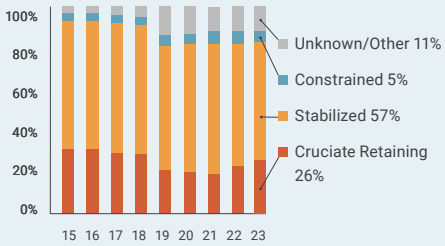
MOBILE VS. FIXED BEARING INSERTS



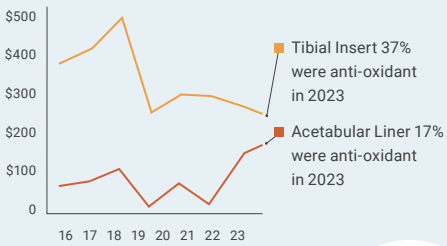
TIBIA INSERT BY MATERIAL



TIBIAL INSERTS BY TYPE



COMPARISON OF PRICE PREMIUMS FOR ANTI-OXIDANT POLYETHYLENES



Bone Cement Use in Total Knees

The use of bone cement in primary knees, identified as Curvo construct 24 (uncoated knee femur/uncoated tibia) was investigated in the CRN. This group included 16,000-32,000 cases annually between 2011 and 2023. The number of 40g packets used per procedure and the prevalence of antibiotic bone cement was examined. Each 40g packet of non-antibiotic bone has a 2023 average selling price of about $58 and manufacturer-provided antibiotic bone cement costs three to four times as much.

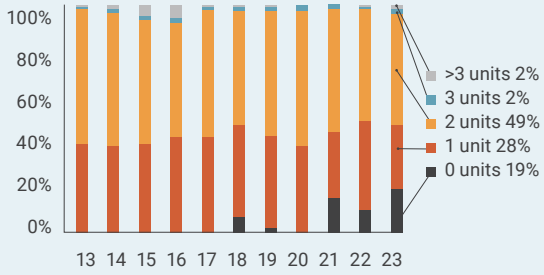
The average number of units of bone cement declined slightly in 2023 from 1.44 to 1.38 units with the percentage of procedures with zero bone cement increasing from 10% to 19%. Twenty-eight percent of the bone cement units were antibiotic bone cement. Note that this applies to a subset of the hospitals that report bone cement on each of their cases. The analysis does not include the amount of antibiotic bone cement that is a result of hospital-based compounding of vancomycin along with standard bone cement. This has been reported as a means of reducing cost. Hospital-based compounding may be increasing as the percentage of CRN cases using antibiotic bone cement has declined from 54% in 2014 to 28% in 2023.

Bone Cement Used in "Cementless" Knees

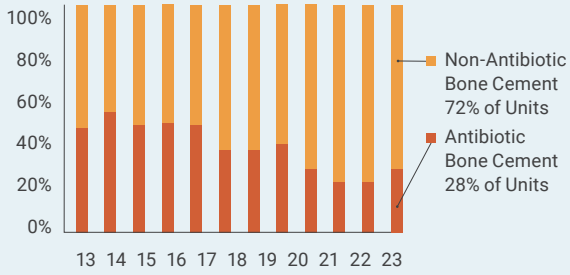
Since 2015, the percentage cementless knees procedures that included cement has hovered between 15 and 20% of the cementless cases. In the 2023 CRN, approximately 37% of the cementless knee procedures included bone cement. It is estimated that this extra bone cement can add between $45 to $500 per case.

Bone Cement Usage in Primary Knee Replacement

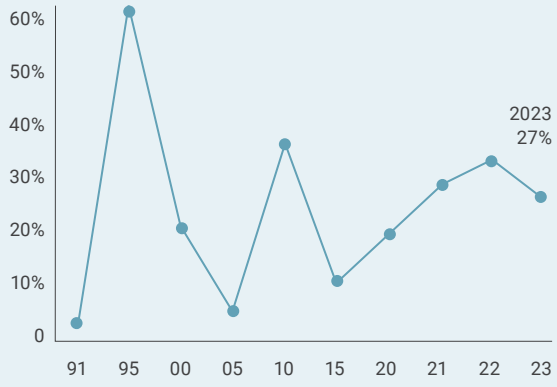
UNITS OF 40G BONE CEMENT USED IN PRIMARY TOTAL KNEE REPLACEMENTS



ANTIBIOTIC BONE CEMENT USED IN PRIMARY TOTAL KNEE REPLACEMENTS



Percent of Porous or "Non-Cemented" Knees that Actually Use Cement



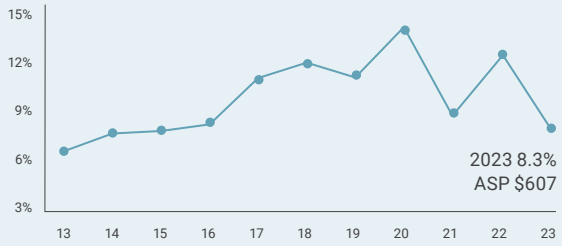
Tibial Stems Used in Primary Knees

Tibial extension stems have been used extensively in revision surgery in which a tibial base plate is removed and an extension stem is attached to a revision tibia to provide greater stability. Stem extensions are also used when there is instability due to compromised collateral ligaments. The cost of these extension stems is not trivial— the cost averaged $607 in the 2023 CRN and the percentage of primary knee cases receiving an extension stem decreased from 10.1% of the cases in 2022 to 8.3% in 2023. The primary manufacturers of tibial extension stems are Zimmer Biomet, Stryker and Total Joint Orthopedics.

Source: CRN

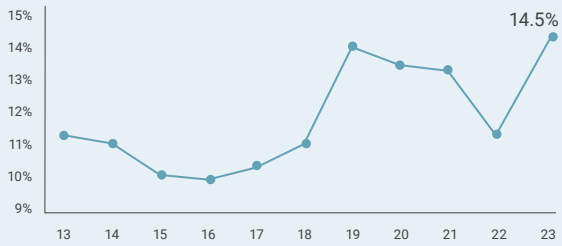
Tibial Stem Extensions in Primary Knee Replacement

PERCENTAGE OF PRIMARY KNEE CASES WITH TIBIAL EXTENSION STEMS

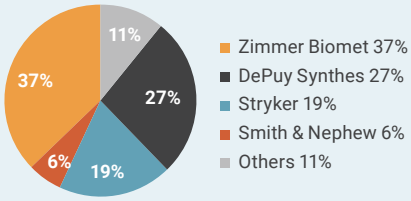


Revision Knee Procedures and Market Shares

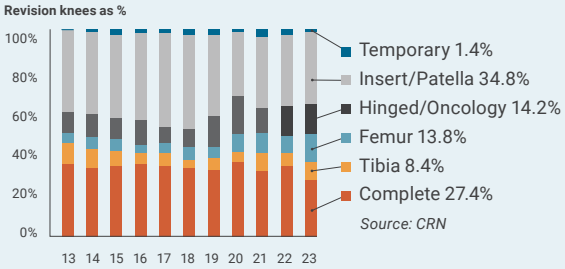
PERCENTAGE OF KNEES THAT ARE REVISIONS IN THE CRN



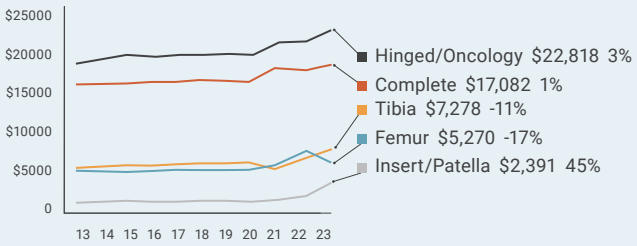
2023 CRN SHARE OF KNEE REVISIONS



TRENDS IN COMPONENTS USED FOR REVISION KNEES



AVERAGE COST FOR REVISION KNEE SYSTEMS



Revision Knees

"Revision knees" are inferred from the data sources provided to Curvo Research Network, which are mostly purchase orders. Some cases may include multiple purchase orders which may look like a revision knee. Where possible these have been excluded from this analysis.

There were 8,650 revision knees in the 2023 CRN (compared to 7,138 in the 2022 CRN). Revision knees as a percentage of all knees were 14.5% in 2023, up from 11.3% in 2022. The largest market share of manufacturers of knee revision systems in the CRN in 2023 was Zimmer Biomet (37%) followed by DePuy Synthes (27%), Stryker (19%), Smith & Nephew (6%), and others (11%).

Curvo classifies knee revisions based on the disruption to the major bones involved: femur and/or tibia. That is, some revisions require a removal and replacement of the femoral component, others require removal/replacement of the tibial component, and some, such as a tibial insert or patellar exchange, disrupts neither femur nor tibia. CRN also includes the OSS and Finn of Zimmer Biomet, the GMRS and MRH from Stryker, the NexGen RHK and MOST from Zimmer Biomet, and the Noiles from DePuy Synthes as hinged/oncology systems. CRN classifies the Vanguard SSK, NexGen LCCK, TC3, Scorpio TS, Triathlon TS as "complete" systems. They may be used in revision or primary procedures.

Based on a review of the 2023 CRN revision knees, the largest number of revisions were for replacement insert/patella systems, which accounted for 34.8% of the cases. Following insert/patella systems were "complete" replacements, which accounted for 27.4% of the revisions, hinged/oncology systems (14.2%), femoral disruptions (13.8%), and tibial disruptions (8.4%). The most expensive systems used for knee revisions in the 2023 CRN were those designated as hinged/oncology systems $22,818, "complete" systems $17,082, femoral disruptions $5,270 and those with tibial disruptions $7,278. "Temporary" implants (not shown in the graph), i.e. those used in two-stage revision procedures averaged $5,697 per case. Those requiring a replacement of either a tibial insert or patella averaged $2,391 for implant components per case. Note that these costs include the costs for bone grafts and substitutes.

As was reported in previous years, the implant costs for a revision knee are ~ 68% more expensive than those for a revision hip — $10,171 vs. $6,066. Given that the revision knees often involve infection and treatment with two-stage procedures, it is logical that increased infection-control vigilance be applied for knee procedures, not only for patient safety issues, but also economic ones.

Data Sources and Methods

In 2022, all of the cases reported in this analysis came from data submitted through either Curvo Labs or through services of Mendenhall, Associates, Inc. The cases and parts are designated as the Curvo Research Network (CRN), previously known as the Orthopedic Research Network (ORN). Most of the data are derived from purchase orders submitted by the hospitals to the manufacturers of orthopedic implants or related suppliers. Between 2019 and 2020, some attempts were made to weed out data from hospitals that didn't represent "true" cases.

Average selling prices (ASPs) are calculated from hospitals submitting detail pricing information. Average selling prices for components in "cap" constructs were calculated based on allocating the total cap prices to components based on the ratio of the list price of the component to the total cap price. ASPs for both components and constructs are calculated.

Data from the current year (i.e. 2022 to 2023) is updated quarterly, since data is received from hospitals on an ongoing basis which is reported in a variety of products and services from Curvo Labs.

There are two files derived from the quarterly update:

(1) Cases: These are the case-level specific information that is used to calculate average selling price by procedure, construct, percentage of cases with bone cement, etc.

(2) Parts: These are the component level data for each part with a sales, hospital usage, and an average selling price.

Number of cases and parts used for reporting this newsletter:

CRN Cases	Hips *	Knees **	Hospitals
2021	48,797	48,453	245
2022	63,322	60,203	200
2023	58,863	64,802	227

Different Parts for CRN Cases	Hips	Knees
2021	336,405	374,261
2022	413,195	505,878
2023	435,675	529,667

Although this may be the largest detailed sample of hip and knee implant cases, these hospitals are self-selected, that is, no claim is made that they are nationally-representative, although informal surveys indicate that the experience with this group is reflective of many national trends.

** Hips include total hips (THA), partial hips, revision hips, resurfacing hips.*
*** Knees include total knees (TKA), unicondylar knees, patellofemoral joint replacements, revision knees*
****Parts include the "hardware" (i.e. femurs, femoral heads, shells, liners, inserts, stems, wedges), as well as bone grafts, bone substitutes, bone cements, and non-implantable devices such as cutting guides.) Some hospitals provide information on these extra components and others do not.*

Robotics in Joint Replacements—A 2024 Update

Stryker's success with robotic surgery since the acquisition of Mako in 2013 has spurred numerous competitors to develop or acquire systems. Sales related to Zimmer Biomet, DePuy Synthes, Smith+Nephew and Corin robotic applications are present in CRN data but are very small in comparison to Mako. Globus is the most recent entry after receiving FDA clearance for the ExcelsiusFlex with Total Knee Arthroplasty in July 2024.

In addition to robotics, companies are investing in enabling technologies related to planning, imaging, navigation, augmented reality and machine learning. Creating an "ecosystem" of enabling technologies and selling to hospitals and ASCs through earn-out arrangements that are paid for through implant purchases.

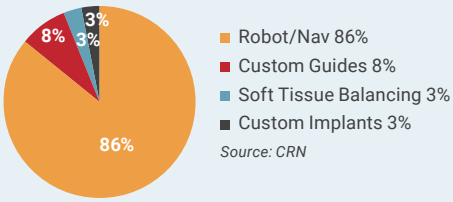
In analyzing the types of digital assistance available, CRN has chosen to include not only the high-profile robots, but also instruments used for soft tissue balancing, custom cutting guides, navigation and custom-made implants and instruments. There are two reasons for this: at present, a very small percentage of procedures are using two competing digital assistance technologies in our data. The second reason is that as the manufacturers of these devices gain acceptance in one specialty—unicondylar knees, for example, it is often a matter of time where they will be deployed for others, such as total hips or spinal fusions.

Of the approximately 14,500 cases with digital assistance that were examined, 86% used a robot or nav, 8% used custom cutting guides, 3% used soft tissue balancing systems, and 3% involved custom designed implants. The procedures that the digital technologies were used in skewed heavily toward total knee replacements, with 70% of the digital devices used in total knees, followed by total hips with 18%, unicondylar knees with 7% and shoulders with 4%. The use of a robot varied considerably by procedure: 50% of the unicondylar knees in the Curvo Research Network (CRN) utilized a robot in 2023, followed by total knees with 13% of the procedures utilizing a robot.

Types of Total Joint Replacement Digital Assistance

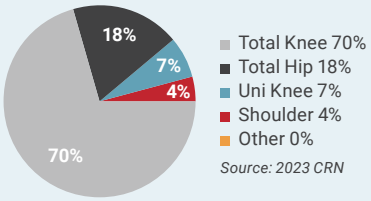
Type Robot/CAS/	Functions	Examples
Provides guidance for Navigation	Mako (Stryker) removing bone/tissue under surgeon supervision	Navio (SNN) ROSA (ZBH) VELYS (DPY) Exactech GPS OMNIBotics (Corin)
Custom Implants	Manufactures implant based on patient specific anatomy	ConforMIS Patient Matched Implants (ZBH)
Custom Cutting Guides	Provides disposable cutting guides based on patient specific anatomy	TruMatch (DePuy) Signature, PSI (ZBH) Visionaire (SNN) MyKnee (Medacta)
Soft Tissue Balancing Devices	Provides feedback on balance of soft tissues during knee replacement	Verasense OrthAlign iAssist (ZBH)

Share of Cases by Digital Assistance Type



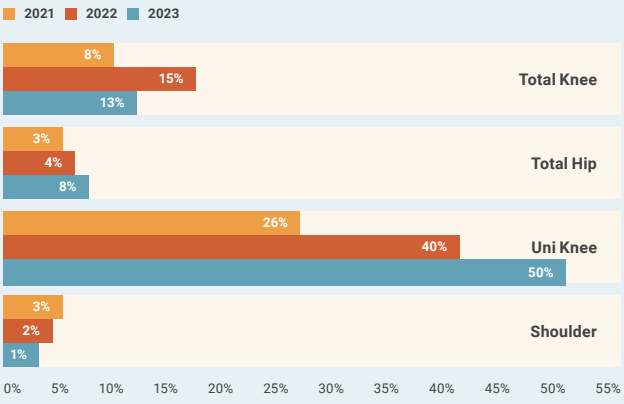
Source: CRN

Digital Assistance by Procedure Type



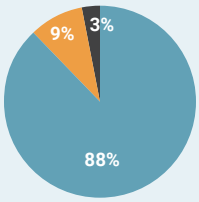
Source: 2023 CRN

Percentage of Joint Replacement Cases Utlizing Robots



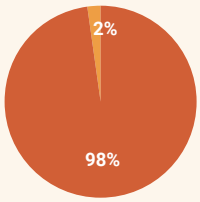
Source: CRN. Percent of cases based on number of trauma cases with osteobiologics, GIC 62, with type1 Allo bone, DBM, Bone subs, BMP, Cell based matrices (CB Matrix), allograft tissue. Distribution of costs for these products.

Robots Used in Joint Replacements



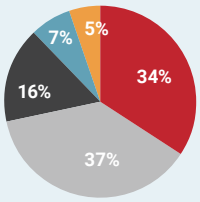
- Stryker (Mako) 8,220 88%
- Zimmer Biomt (ROSA) 851 9%
- DePuy Synthes (Velys) 276 3%
- Smith & Nephew (Navio) 42 0%

"Custom" Implants



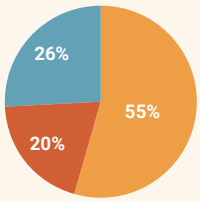
- Conformis 98%
- Kinamed Kinematch 2%

Custom Cutting Guides



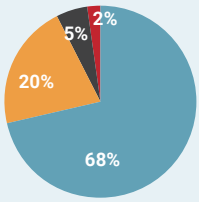
- Signature/PSI 34%
- BluePrint 37%
- Visionaire 16%
- TruMatch 7%
- Match Point 5%

Soft Tissue Balancing Devices



- i-Assist 55%
- KneeAlign 20%
- Verasense 26%

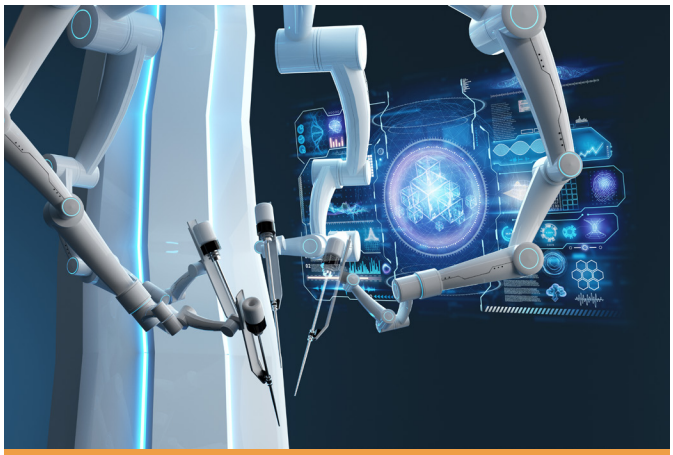
Navigation



- NaviTrackER 68%
- OrthoLock 20%
- JointPoint 5%
- iMNS 2%

Of the different types of devices, Stryker's Mako dominates the robot sector with 88% of the cases in the CRN, followed by Zimmer Biomet's Rosa with 9%, DePuy Synthes Velys with 3% and S&N Navio with less than 1%. ConforMIS is the market for custom implants with a small contribution from Kinamed Kinematch. Custom cutting guides were led by Stryker's BluePrint with 37% followed by Zimmer Biomet's Signature and Patient Specific Instruments with 34%, Smith & Nephew's Visionaire with 16% and DePuy Synthes' TruMatch with 7% and Enovis Match Point with 5%.

Soft tissue balancing devices were led by Zimmer Biomet's iAssist with 55%, followed by OrthAlign's Knee Align with 20% of the cases and Stryker/OrthoSensor's Verasense with 26% of the cases. Navigated procedures were led by Zimmer Biomet's NaviTrackER with 68%, followed by Stryker's OrthoLock with 20%, DePuy Synthes JointPoint with 5% and Medacta's iMNS with 2%. 89% of the navigated procedures related to total knee and 5.5% of total knee procedures were navigated.



Caveats on Market Shares

Data for this article was taken from the 2023 Curvo Research Network (CRN), which obtained case information more than 130 hospitals in 2023. For each of the robots, certain part numbers were identified as markers of a robot, such as the Vizadisc from Stryker, and specialized bone pins for the Rosa and Navio. Even if a robot is identified through the unique disposables used on the case, there is no understanding of the degree to which a robot was used in completing the surgical procedure. As such, the estimates presented here are our "best guesses" on the volume of cases and market shares for the different types of devices.

OrthoTrends 2015–2024/Q1

The data for the OrthoTrends are taken from the Curvo Research Network (previously known as the Orthopedic Research Network), a quarterly database of purchasing and clinical data submitted to Curvo Research Network and Curvo Labs. There were over 24,000 cases in 2024/Q1 from 119 hospitals for joint replacements, trauma, spinal fusions. The purchase data includes more than $168 million in spend. The number of cases and amount of spend will vary from quarter to quarter depending on how data is received by the hospitals submitting.

Hip Replacements

Construct Mix: Coated hip stems with either a metal or ceramic head, shell and poly liner accounted for about 83% of the total hips in the CRN in 2024/Q1. The remaining 18% include those with cemented hip stems and resurfacing hips. The average selling price (ASP) of a ceramic-headed system was $5,313, up 7% from 2023 and a metal-headed system was $4,912, up 1% from 2023.

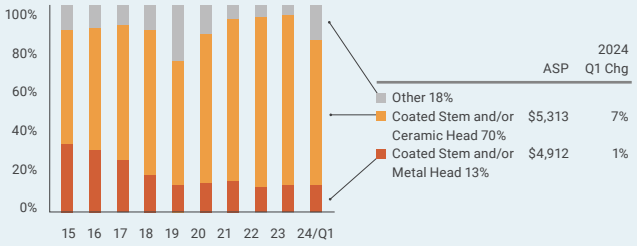
Femoral Stems: Femoral hip stems were primarily coated hip stems, representing 82% of the hip stems sold, with an average selling price of $1,939. Uncoated (cemented) hip stems accounted for 12% of stems, and revision/long stems were 6% of the total. The ASPs for uncoated stems were $1,337, and revision/long stems were $7,260.

Femoral Heads: Ceramic femoral heads accounted for 73% of the femoral heads sold through 2024/Q1 in the CRN. These had an ASP of $958, down 2% from 2023 compared to $545 for metal heads, which increased 4% from 2023.

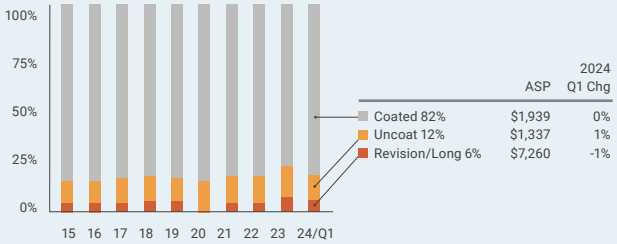
Femoral Head Size: Consistent with prior year, 46% of femoral head were 36mm with an ASP of $898, up 2% from 2023. Smaller heads cost the least at $788.

Key Factors in Total Hips 2015-2024/Q1

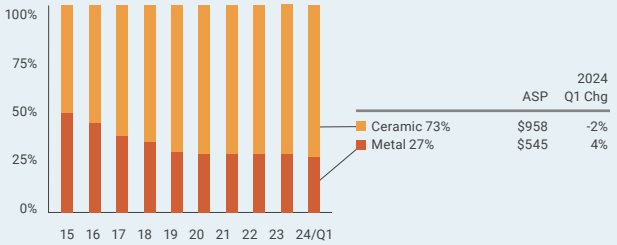
TOTAL HIP CASES BY CONSTRUCT TYPE



TYPES OF HIP STEMS

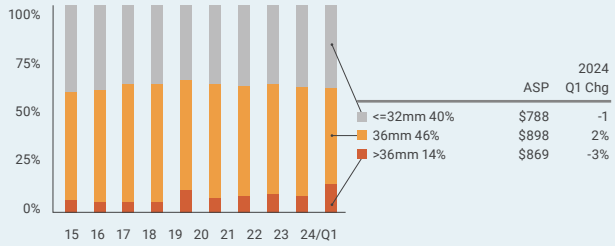


TYPES OF FEMORAL HEADS



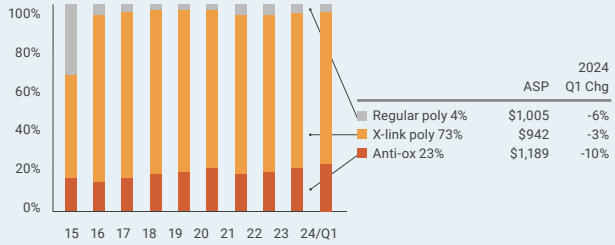
Key Factors in Total Hips 2015-2024/Q1 *continued*

FEMORAL HEAD SIZE



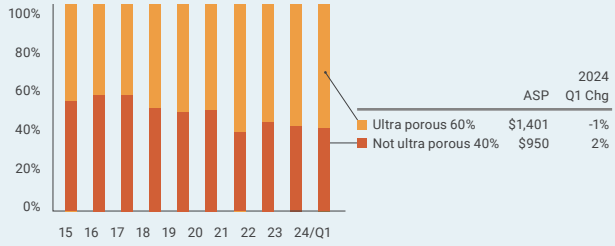
	ASP	2024 Q1 Chg
<=32mm 40%	$788	-1
36mm 46%	$898	2%
>36mm 14%	$869	-3%

ACETABULAR LINERS MATERIAL



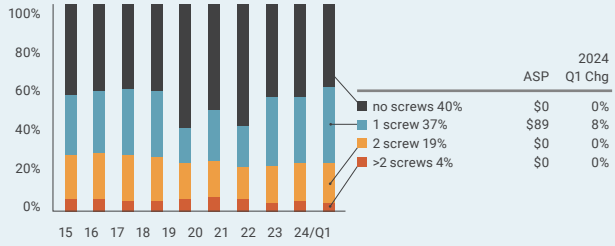
	ASP	2024 Q1 Chg
Regular poly 4%	$1,005	-6%
X-link poly 73%	$942	-3%
Anti-ox 23%	$1,189	-10%

ACETABULAR SHELL MATERIAL



	ASP	2024 Q1 Chg
Ultra porous 60%	$1,401	-1%
Not ultra porous 40%	$950	2%

ACETABULAR SCREW USAGE



	ASP	2024 Q1 Chg
no screws 40%	$0	0%
1 screw 37%	$89	8%
2 screw 19%	$0	0%
>2 screws 4%	$0	0%

Acetabular Liners: Anti-oxidant liners accounted for 23% of the acetabular liners in 2024/Q1 compared to 73% for the crosslinked poly liners. Anti-oxidant liner ASPs were $1,189 compared to $942 for cross-linked and $1,005 for regular poly liners.

Acetabular Shells: 60% of the acetabular shells sold in 2024/Q1 were ultraporous with a price of $1,401 compared to $950 for nonultra porous shells. Ultraporous shells are designed to increase the surface area for the bone to grow into, thus providing a more secure foundation for the cup in the pelvis.

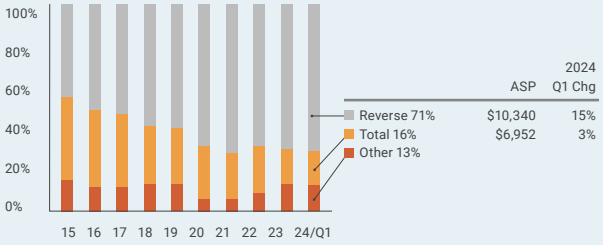
Acetabular Screws: Acetabular screws are used to augment fixation of acetabular shells. In the 2024/Q1 CRN, 40% of the cases had no screws, 37% had one screw, 19% had two screws, and 4% had more than 2 screws. Each screw averaged $89.

Shoulder Replacements

Construct Mix: Reverse shoulders accounted for about 71% of the shoulder replacements in 2024/Q1 with an ASP of $10,340 compared to $6,952 for a total shoulder. Total shoulders accounted for 16% of the implanted shoulders, and partial shoulders, once the second largest group of shoulders accounted for 13% of the cases

Shoulder Key Factors, 2015-2024/Q1

SHOULDER CONSTRUCTS



	ASP	2024 Q1 Chg
Reverse 71%	$10,340	15%
Total 16%	$6,952	3%
Other 13%		

Knee Replacements

Construct Mix: Cementless knees accounted for 21% of the total knees in 2024/Q1 CRN, down slightly from 22% in 2023. Cementless knee ASP was $4,516, compared to $4,406 for the cemented knees which accounted for 76% of the total knees. Partial knees accounted for 3% of the cases with an ASP of $4,311.

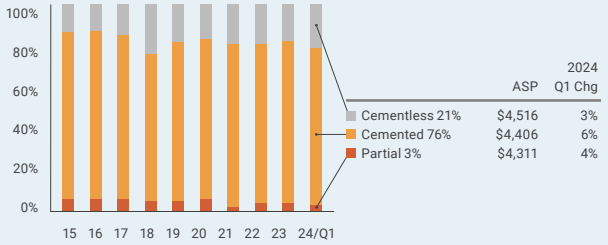
Tibial Inserts: Though there is not as much difference in costs as there used to be, the material composition of tibial inserts is a significant differentiator. Anti-oxident polyethylenes accounted for 45% of the tibial inserts in 2024/Q1 CRN with an ASP of $1,061, compared to cross-linked poly with accounted for 43% of the inserts with an ASP of $943.

Bone Cement: Although bone cement can be used for a variety of orthopedic procedures, the vast majority is used in cemented knees. Twenty six percent of the cemented knee cases had a single 40g pack of bone cement; 68% had two, and 6% had more than two packs. The use of antibiotic bone cement has tracked downward since 2013 but bumped up a bit in 2024/Q1; in the 2024/Q1 CRN, antibiotic bone cement units used on knee replacements accounted for 37% of the units, with an ASP of $191.

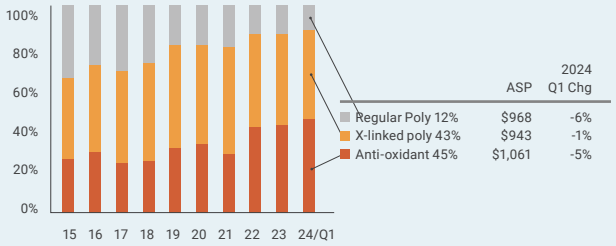
Tibial Extension Stems: Tibial extension stems can add stability to a tibial baseplate, and some, such as Stryker's Triathlon TS or Zimmer's Persona can accommodate either a long extension stem or a simple "cap" on the bottom of the tibia. Tibial extension stems were used in about 6.5% of the total knee procedures in the 2024/Q1 CRN, with an ASP of $750.

Total Knees Key Factors, 2015-2024/Q1

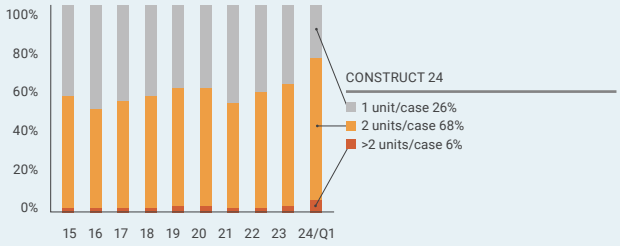
KNEE CONSTRUCTS



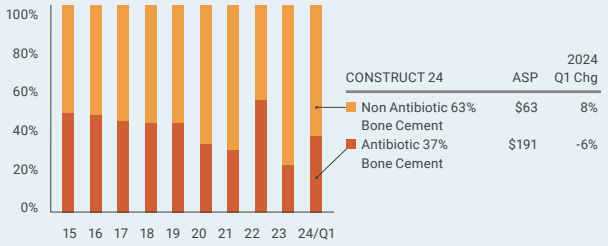
TIBIAL INSERTS BY MATERIAL



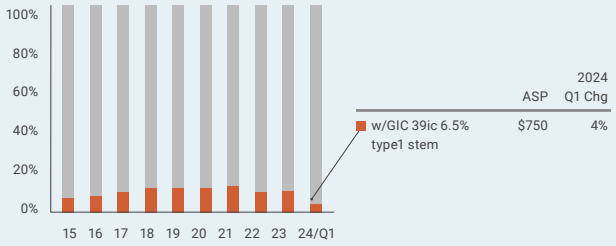
UNITS OF 40G BONE CEMENT USED IN PRIMARY TOTAL KNEE REPLACEMENTS



ANTIBIOTIC BONE CEMENT IN TOTAL KNEES



PRIMARY KNEE CASES WITH TIBIAL EXTENSION STEMS



Lumbar Fusions

Lumbar Fusions Levels Fused: Seventy-seven percent of the lumbar fusions involve either one or two levels, and 23% of the cases fused three or more vertebra in 2024/Q1. The levels are estimated based on the starting and ending vertebral body listed for the case, and hence may not reflect the number of levels that were actually instrumented during the surgery. The ASP of the cases increased with the number of levels fused from $11,596 for a single level, $14,691 for a two-level fusion, and $15,608 for a three-level fusion case.

Treatment of Single Level Lumbar Fusions: The most common treatment for a single level lumbar fusion is a pedicle screw construct with an interbody fusion device, which accounted for 60% of the single level lumbar fusions. This was followed by pedicle screw constructs (28%), and interbody only (11%). Pedicle screw plus interbody constructs are the most costly at $13,789. Plate plus interbody cost $11,006, followed by interbody-only at $10,999 and pedicle screw-only at $7,907.

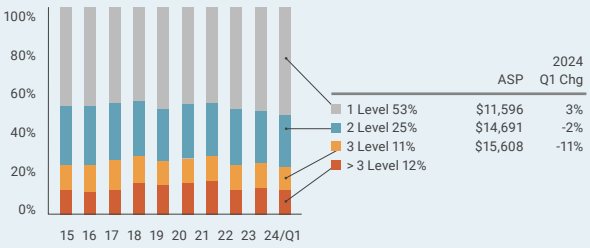
Resources: Metals (rods, plates, and screws) accounting for 38% of the costs of single level lumbar fusions is followed by interbody fusion devices at 32%, biologics follows at 23% and the remaining 7% relates to instruments, monitoring disposables and other misc.

Biologics: There are literally hundreds of osteobiologics that are used in spine procedures. Among the most costly are BMPs (which include Medtronic's Infuse as well as Cerapedics i-Factor), and cell-based matrices (e.g. Vivegen, Trinity Elite). Others include variations of demineralized bone matrix, bone substitutes, and allograft bone. BMP-only was used in 10% of the lumbar fusions in 2024/Q1, cell-based matrices-only in 5% of the cases, DBM or BGS in 20% and two or more biologics in combination were used in 27% of the cases. Thirty eight percent of the cases did not use one of these more expensive biologics but may have used autograft or inexpensive traditional allograft chips. ASPs for BMP-only cases were $4,453, CBM $4,460, DBM or BGS $1,924 and the cases with multiple biologics used in combination had an ASP of $8,344 per case.

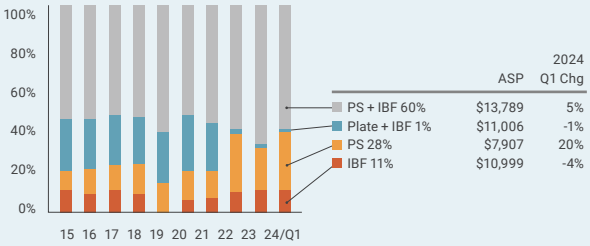
The size of the dosage of BMP has a large impact on the cost per case. Use of the smaller sizes (XXSM and XSM) was up significantly in Q1. The smallest sizes averaged about $1,544 in 2023 and the largest average $5,303. In the 2024/Q1 CRN, XXSM or XSM sized BMP accounted for 34% of the mix compared to 49% for small, and 17% for medium/large/extra-large. The overall cost per purchase averaged $3,517 in 2024/Q1, down 16% from 2023.

Lumbar Fusions, 2015-2024/Q1

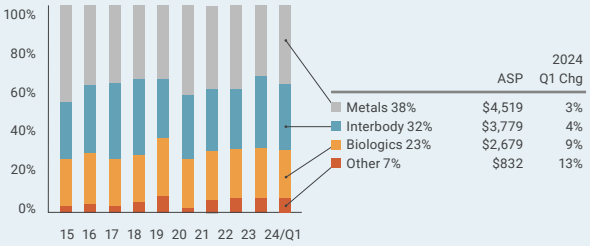
LUMBAR FUSION LEVELS



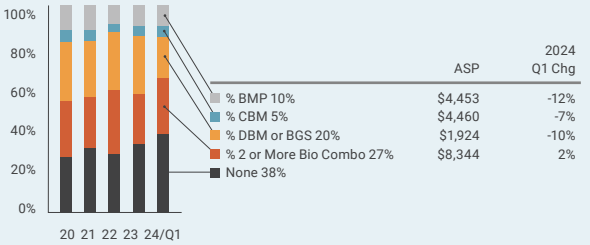
1-LEVEL LUMBAR FUSION IMPLANT $/CASE BY TYPE



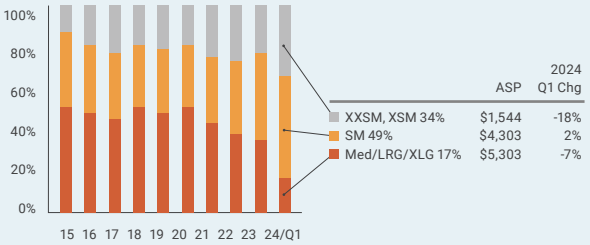
TREATMENT OF SINGLE LEVEL LUMBAR FUSION



BIOLOGICS IN LUMBAR FUSION



BMP SIZE DISTRIBUTION



Cervical Fusions

Levels Fused: Thirty-nine percent of the cervical fusions involved three or more vertebrae in 2024/Q1, while one- and two-level fusions accounted for 65% of the cases. The ASP of the cases increases with the number of levels fused from $3,855 for a single level, $4,697 for a two-level fusion and $6,804 for a three-level fusion. The mix of cervical levels fused has shifted as more one and two-level cervical procedures are treated with cervical disc and/or moved from the hospital to an ASC setting. In 2011 approximately 80% of cervical fusions were one or two-level compared with 65% for 2024/Q1.

Treatment of Single Level Cervical Fusions: Fifty-eight percent of the single level cervical fusion cases were treated with a combination of interbody fusion device and a cervical plate in 2024/Q1, interbody-only accounted for 17% of the cases, and posterior cervical cases represented 14% of the total. Plate-only cases accounted for 10% of the single-level cervical fusions in 2024/Q1.

Resources for Single Level Cervical Fusions: The most expensive components of the cervical fusions were the plates and screws which accounted for 47% of the costs of the cervical fusions, and the interbody fusion devices which accounted for an additional 37% of the total. Osteobiologics, and "other" accounted for the remaining 16% of the costs.

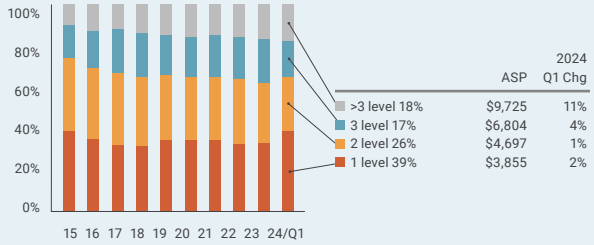
Trauma

Hip Fracture Treatment: There are a variety of modalities available to treat hip fractures, although treatment will depend on the location of the fracture and available resources. Although it is not possible to definitively say how hip fractures are treated in the hospitals contributing data to the CRN, the modalities listed above are generally used for the treatment of hip fractures. According to the 2024/Q1 CRN, the most frequent treatment modality were troch nails which accounted for 48% of the cases, followed by bipolar hips at 26%, hip pins at 12% and modular endoprostheses at 9%. The highest ASPs for the cases were modular endoprostheses $3,344 followed by bipolar hips $3,286 and troch nails $3,154.

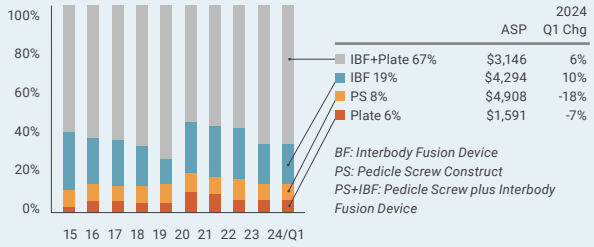
Source: All data on this page, Curvo Research Network (CRN)

Cervical Fusions, 2015-2024/Q1

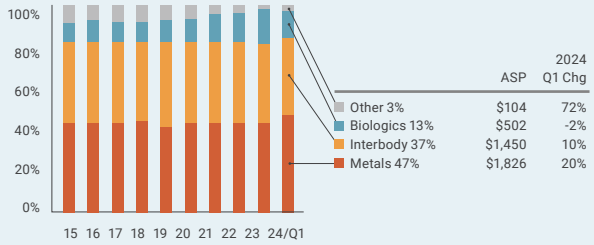
CFU01 NUMBER OF LEVELS FUSED IN THE CERVICAL SPINE



CFU03 1-LEVEL CERVICAL FUSION TREATMENT

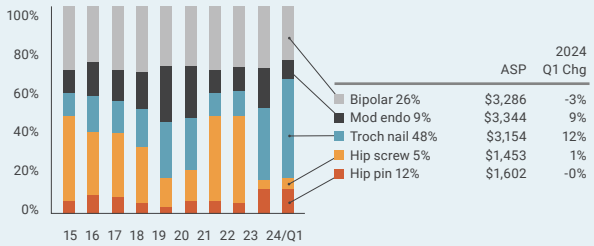


CFU02 1-LEVEL CERVICAL FUSION IMPLANT $/CASE, BY TYPE



Trauma Devices 2015-2024/Q1

PERCENT OF CASES BY TREATMENT TYPE



ABOUT THE SAMPLE

Cases examined in the database for this article:

	CY 2023	Q1 2024	Q1/2024 Hospitals
Total hips	23,487	6,111	110
Total Knees	38,570	9,134	113
Shoulders	10,788	2,206	94
Lumbar Fusions	16,175	2,678	55
Cervical Fusions	9,207	1,720	55
Hip Fracture Constructs	9,230	2,744	102

Cases are excluded from the analysis if it appears that the data does not reflect bona fide cases.

2024 Newsletter Topics

Volume 35, Number 1 (Available)
Extremity

Volume 35, Number 2 (Available)
Trauma

Volume 35, Number 3 (Available)
Hip and Knee Implants

Volume 35, Number 4 (Coming Soon)
Spinal Surgery, Bone Grafts and Substitutes

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