4 Epidemiology and Demographics of Reverse Shoulder Arthroplasty

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4.1 Introduction

Since the first documented shoulder arthroplasty in 1893 [1], there have been many advances in shoulder implants, particularly within the last two decades. Shoulder arthroplasty has become the established treatment for severe glenohumeral disease from rheumatoid arthritis (RA) to osteoarthritis (OA), severe fracture, avascular necrosis (AVN), and cuff tear arthropathy. Various implant designs have been developed over the past 20 years resulting in a large number of available implants. Due to increased life expectancy and greater demand from the aging society for optimal quality of life into advanced old age, shoulder arthroplasty has become more popular worldwide [2, 3]. The widespread of shoulder arthroplasty is more recent than that of hip and knee arthroplasty, the incidence is 7.5-fold lower, and the range of disease indication is wider [4]. Hip and knee arthroplasty is more common (40% of patients) in non-elderly adult patients compared to shoulder arthroplasty, in which 30% of patients are non-elderly [5]. The occurrences of hip and knee arthroplasty are increasing faster among the middle-aged population (45–64 years) than in the elderly population, while shoulder arthroplasty is a phenomenon that primarily affects the elderly [2]. The introduction of reverse total shoulder arthroplasty (rTSA) is one of the factors responsible for the predominance of elderly patients among those who are managed with TSA. Currently, rTSA is recommended predominantly for patients over 70 years old with disabling rotator cuff arthropathy [6]. However, a wider range of pathologies and complications, such as revision of failed anatomic total shoulder arthroplasty (aTSA) or hemiarthroplasty (HA), are nowadays managed with rTSA. Therefore, the increase in rTSA cases may be due in part to broader emerging indications [2]. Identifying actual epidemiology and demographics of rTSA may be difficult because of the poor data available in literature studies. In fact, while hundreds of thousands of shoulder arthroplasties are performed each year around the world, data are available on very few of them. Most of the publications on shoulder arthroplasty procedure and outcomes are published by a relatively small number of medical centers, which may not be representative of the situation on national or global scale [7].

Registries may thus provide the most reliable evidence on rTSA epidemiology and demographics [7].

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4.2 Shoulder Arthroplasty Epidemiology Before rTSA Separate Coding in National Shoulder Arthroplasty Registers

Until recently, rTSA was coded as aTSA in different national registers. In the USA, the option for separate coding of rTSA and aTSA was implemented only in 2011 despite rTSA approval by the Food and Drug Administration (FDA) in 2003. According to US data reported by Kim et al. [2], in 1993 the total number of shoulder arthroplasties was 13,873, of which 7,545 (54.4%) HA and 6292 (45.6%) TSA (rTSA + aTSA) [2]. In 2003 the total number of shoulder arthroplasties doubled to 25,948 cases, of which 15,290 (58.9%) HA and 10,658 (41.1%) TSA (rTSA and aTSA) [2]. In 2006, short after the approval of rTSA by the FDA (2003), the number of TSA cases in the USA (20,086) became higher than the HA cases (18,052) for the first time. In 2008, of 46,951 shoulder arthroplasties implanted in the USA, 57% were TSA (26,773 cases) and 43% were HA (20,178 cases).

The number of shoulder arthroplasties performed in the USA indicated a 2.5-fold increase over the decade between years 1998 (19,000 cases) and 2008 (nearly 47,000) [8]. During this time, the elderly population increased approximately by 11%, and the number of surgeons implanting shoulder arthroplasties increased by 24% [2]. However, the augmented number in shoulder arthroplasty cases was much steeper than the growth of the elderly population or the density of orthopedic surgeons in the USA, suggesting that multiple other factors were responsible for this result. Kim et al. [2] suggested that the abrupt increase in TSA but a steadily growing HA since 2003 was due to the FDA approval of rTSA in 2003 [2] (Fig. 4.1). The same trend can be noticed in the German experience [9]. In Germany, the option to code rTSA was introduced in 2008. In 2005 the number of shoulder arthroplasties implanted was 7781, of which 5460 (70.2%) were HA and 2321 (29.8%) were TSA (rTSA + aTSA). In 2007, of 10,268 shoulder arthroplasties, 6640 (64.7%) were HA, and 628 (35.3%) were TSA (rTSA and aTSA). Since 2008 the number of TSA cases exceeded that of the HA cases, reaching in 2012 a total number of HA of 5975 and TSA 21340. Moreover, in the period 2005–2012, HA number showed an increase until 2008 followed by a continuous decrease, while TSA number increased over the years [9].

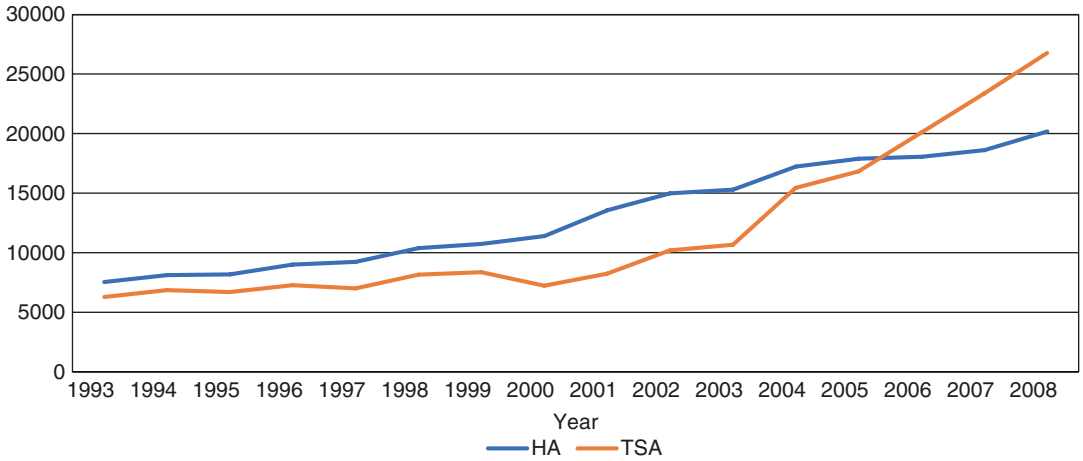

Fig. 4.1 Graphic illustrating annual implant rate for HA (hemiarthroplasty) and TSA (total shoulder arthroplasty) between 1993 and 2008 in the USA. Data from Kim et al. [2]

4.3 Epidemiology and Demographics of rTSA in National Shoulder Arthroplasty Registers

In the USA, the option to code rTSA was introduced in 2011 for the first time. Based on the Nationwide Inpatient Sample (NIS), 66,485 patients underwent shoulder arthroplasty in the USA in 2011, respectively, 21,692 (32.6%) rTSA, 29,359 (44%) aTSA, and 15,434 (23%) HA [10]. The incidence of shoulder arthroplasty nearly doubled in year 2011 (54.4/10^5 per year) compared to year 2002 (24.5/10^5 per year) [10]. The number of HA decreased from 14.5/10^5 per year in 2002 to 12.6/10^5 per year in 2011. The number of aTSA increased from 14.5/10^5 per year in 2002 to 24/10^5 per year in 2011 [10]. In 2011, the incidence of rTSA was 17.8/10^5 per year [10].

The mean age of patients undergoing rTSA was 71 years, and females represented 63.68% of the patients [11]. The main pathologies leading to rTSA were osteoarthritis (43.67%), disorders of the bursae and tendons (14.03%), cuff tear arthropathy (11.83%), and fractures of the proximal humerus (9.36%).

The Australian national shoulder register started in 2004 but only in 2008 was widespread among all territories in Australia [12]. From 2008 to 2015, the total number of rTSA implanted was 12,362, with an increase of 2680 procedures in 2015 compared to 2014. Primary rTSA increased from 43.3% of all shoulder arthroplasties in 2008 to 64.1% in 2015. In 2012 there were more rTSA implanted than aTSA for the first time. Since 2008 gender distribution had a minor change, with 65.9% of cases in females and 34.1% in males. The mean age was 75.8 years for females and 73.4 years for males. The percentage of patients over 75 years old declined from 61.4% in 2010 to 51.9% in 2015. The main pathologies leading to rTSA were osteoarthritis (43.8%), rotator cuff arthropathy (34.1%), and fracture (14.6%). The diagnosis of osteoarthritis in rTSA declined from 57.8% in 2008 to 43.8% in 2015, while the diagnosis of rotator cuff arthropathy increased from 21% in 2008 to 34.1% in 2015. Regarding HA, the procedure had a drop from 30% to 10% between 2008 and 2014.

Norway is the first country in which the shoulder arthroplasty register was introduced in 1994 [11]. From 1994 to 2006, the total number of shoulder arthroplasties implanted was 2308, of which 301 (13%) were rTSA. In 2010, the percentage of rTSA (140/490; 28.57%) doubled with respect to the period between 1994 and 2001. Likely, in 2015 the percentage of rTSA reached 53.9% (377/700), reporting an increase in popularity of rTSA over the last 15 years. Conversely, HA number showed a significant decrease passing from 220 cases/year in 2006–2012 to 150 cases/year in 2013–2014 [11] (Fig. 4.2). Reverse TSA was implanted as a primary procedure in the majority of cases throughout the whole period considered. As far as surgical indication is concerned, from 1994 to 2015, the main pathologies leading to rTSA implantation were (1) proximal humerus fracture in 696 (33.6%) patients, (2) idiopathic osteoarthritis in 607 (29.3%) patients, (3) rheumatoid arthritis in 330 (15.9%) patients, and (4) rotator cuff arthropathy in 258 (12.4%) patients. There is no available data reported on the mean age and gender for rTSA on this registry (Fig. 4.3).

In the UK, data collection for the national shoulder arthroplasty registry began in 1 April 2012 [13]. Since then 9968 (42.2%) rTSA have been implanted. The mean age of patients who received rTSA was 76 years. The vast majority of patients were females. The number of rTSA implants has increased from 806 (31.7%) reported in 2012 to 3015 (50.7%) in 2016 [13]. The main pathologies leading to rTSA were (1) rotator cuff arthropathy (50.5%), (2) osteoarthritis (24.8%), (3) acute fractures of the proximal humerus (9.7%), (4) trauma sequelae (8%), and (5) inflammatory arthritis (3.4%) [13].

According to the New Zealand national shoulder arthroplasty registry, from January 2000 to December 2013 there were 5528 primary shoulder arthroplasties implanted, of which 1553 (28%)

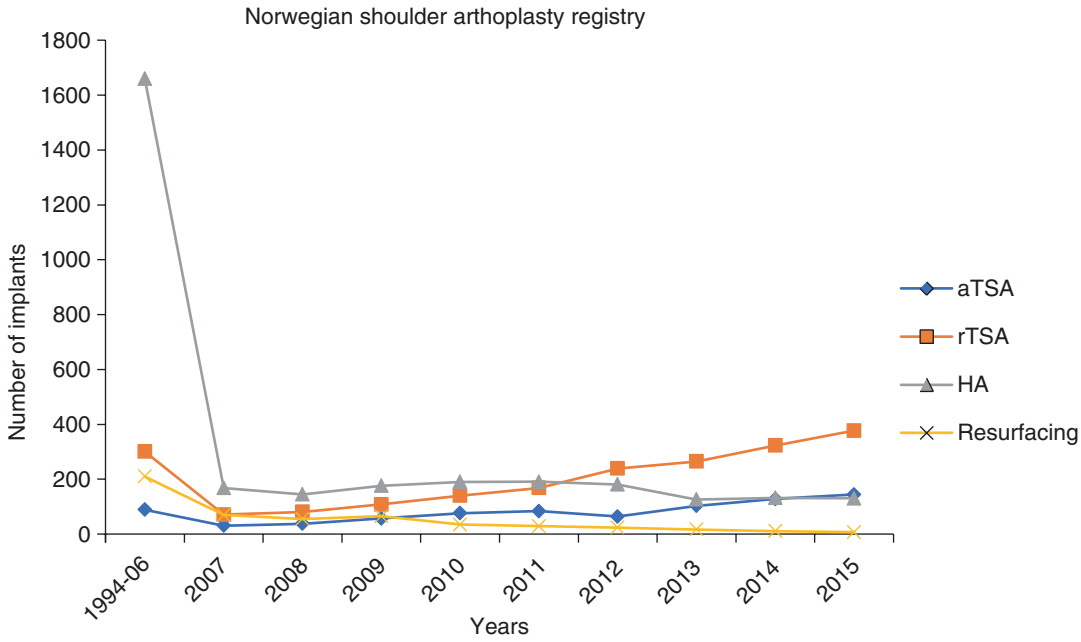

Fig 4.2 Graphic illustrating annual variation in shoulder arthroplasty implant between 1994 and 2015. Data from Norway national shoulder arthroplasty registry

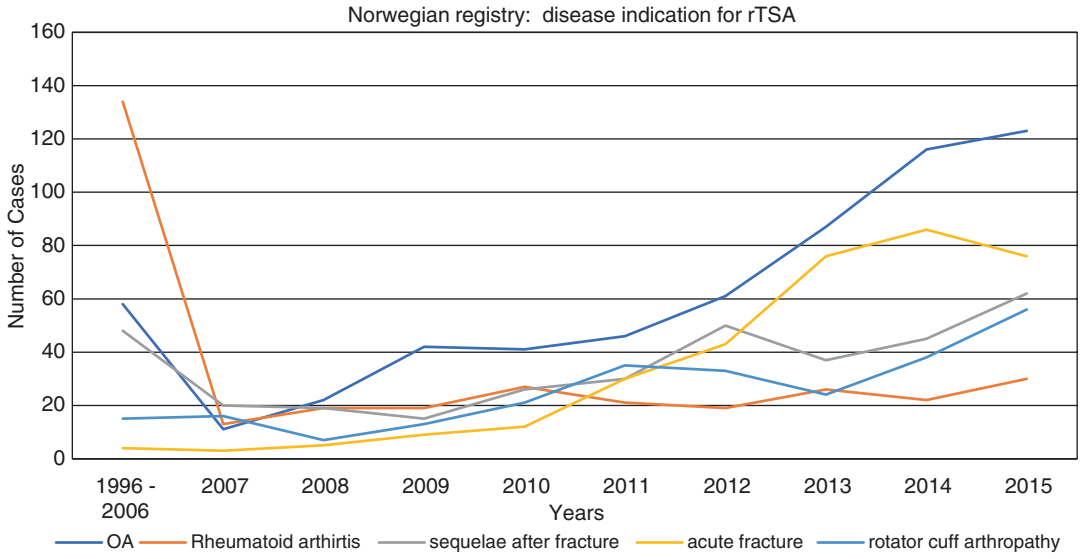

Fig 4.3 Graphic illustrating annual variation of disease indication for rTSA in Norway between 1996 and 2015. Data from Norway national shoulder arthroplasty registry

were rTSA (63.75% females and 36.25% males) [14]. Lübbeke et al. [15] recently reported in New Zealand an increase of rTSA from 2% in 2002 to 56% in 2012, although indications for surgery were not reported [15].

Germany has the highest incidence rate (34/10^5 per year) of shoulder arthroplasty among countries with available national data (mean incidence 13.3/10^5 per year) [15]. The option to code rTSA was introduced in 2008. Between January 2008

and December 2012, the number of rTSA implanted was 27,011, with a tremendous increase in the number of cases over the years from 2008 to 2012. For example, in 2008 the number of rTSA implanted was 2935 while in 2012 was 8011, nearly a 273% increase. Women represented the vast majority of patients who underwent rTSA (75.5%). The main pathologies leading to rTSA were osteoarthritis (male 70.7%; female 58.97%), fracture of proximal humerus (male 18.5%; female 33.93%), and cuff tear arthropathy (male 9.21%; female 5.22%). Due to inconclusive information regarding causative pathology, 20% of the patients were not assigned to an indication group. Differently from previously considered registries, the ratio of aTSA/rTSA is in favor of anatomic implants (65/35). Anyway, since 2008 this ratio has become less divergent because of a relative increase of rTSA [16].

The study conducted by Bayona et al. [7] on national shoulder arthroplasty registers available concluded that shoulder arthroplasty indications have an important geographical variation that should be considered when comparing outcomes from different locations. Moreover, heterogeneity of information regarding diagnosis, age, gender, and procedure type in different registries, together with variable length of data collection, might lead to unease registries comparison [8].

Lübbeke et al. compared data within registries and from different registries regarding aTSA and rTSA as well as HA at different points in time. Considering all the national and regional registers available, rTSA was most commonly used in Norway, Australia, and the UK, HA in Scandinavia, and aTSA in New Zealand, California, and Germany [10–15]. The use of rTSA over the last 15 years in Norway and New Zealand increased from 12% to 52% and from 2% to 56%, respectively, whereas in Sweden its use remained stable (6–10%) over the examined period [11, 14, 15].

The distinction of different disease indications for each implant in national registers begun in recent years (from 2008 on, with the exception of California and Denmark). To quantify how much the different procedures varied across registries, Lübbeke et al. used meta-analysis techniques and evaluated the three most common disease-implant combinations, which were OA-aTSA, cuff tear arthropathy-rTSA, and fracture-HA. [15]. In the study conducted by Lübbeke et al. [15] for rTSA in patients with cuff tear arthropathy, the combined proportion was 77% (confidence interval 60–91). The variability between registers was relevant, and the prediction interval was from 13 to 100% [15]. A similar wide variability in indications was noted also for the other disease-implant combinations [15]. This large variation for different procedures could be related to the lack of long-term data and international guidelines.

4.4 Epidemiology and Demographics of TSA and rTSA in Italy

The national shoulder registry in Italy was introduced in 2001, with aTSA and rTSA codified as the same procedure since then. Since 2001 the total number of shoulder arthroplasties has increased, from 1539 in 2001 to 6588 in 2015 [17] (Fig. 4.4) (Table 4.1). During the last 15 years, the number of HA has increased until 2010 and has stabilized since then. The proportion of HA has rapidly decreased from 54.84% in 2001 to 19.44% in 2014, while the total number of shoulder arthroplasty and the number of TSA has proportionally increased (Table 4.1).

In the Italian scenario, a regional shoulder arthroplasty register with a different coding for aTSA and rTSA can be found. In fact, in Emilia-Romagna (a region of 4.5 million inhabitants in northeast Italy), separate coding was introduced in 2008 [17, 18] (Fig. 4.5). Between 2008 and 2015, 2855 shoulder arthroplasties out of 4653 (61.4%) were rTSA. Since 2008 the number of rTSA implanted has encountered a continuous increase, while HA is decreasing since 2011 (Table 4.1). For rTSA, female gender prevails with 2208 implants (77.3%) versus 647 (22.7%). The mean age of patients at surgery was 71.8 years for males and 74.1 for females.

The main disease indication for rTSA is eccentric osteoarthritis in 1495 cases (52.4%), proximal fracture management in 544 cases (19.1%), concentric osteoarthritis in 417 cases

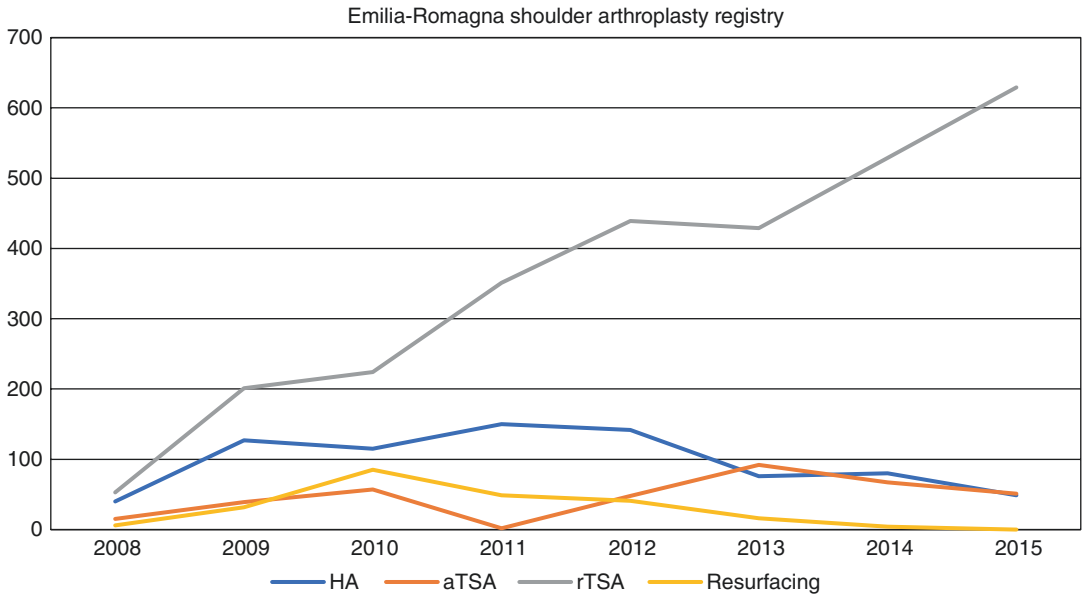

Fig 4.4 Graphic illustrating annual variation in shoulder arthroplasty implant between 2007 and 2014 in Italy. Data from Italian arthroplasty registry (RIAP)

(14.6%), cuff tear arthropathy in 82 cases (2.9%), sequelae of fractures in 78 cases (2.7%), and avascular necrosis of the humeral head in 67 cases (2.3%). The main indication for aTSA is concentric osteoarthritis, accounting for 80.9% of cases in the aTSA group. Conversely, the main indication for HA is fracture, accounting for 63.4% of cases in the HA group [15, 18].

4.5 Conclusions

Shoulder arthroplasty has seen a rapid acceleration in clinical application in the past two decades in the developed countries [2, 7, 15], although its incidence remains lower compared to hip and knee arthroplasty. The increase of rTSA implants seems to be at least partially responsible for this phenomenon [2, 7, 15]. Although reverse TSA has been primarily indicated in patients with rotator cuff arthropathy, a recent broadening of clinical indications has been documented. These factors coupled with the progressive aging of the population could be an acceptable explanation for the increase of rTSA implantation [2]. Several differences in indications for rTSA and relative use of rTSA compared to other implants emerge from different shoulder arthroplasty registers examinations. The steep increase in shoulder arthroplasty worldwide is not accompanied by a paired availability of published data. Outcomes published in the literature on shoulder arthroplasty are based on small series from a limited number of centers, nonreflecting the international practice. National shoulder registries can conversely provide important information on shoulder arthroplasty use in different countries, although they present some limitations especially regarding clinical indication for rTSA together with clinical and radiographic outcomes. Broadening of standardized and nationally founded shoulder arthroplasty registers could provide a better overview on today's practice and standardize shoulder arthroplasty indications in the future.

Table 4.1 Summary of data reported in the national shoulder arthroplasty registers of Italy, the UK, the USA, Germany, Australia, Norway, and Emilia-Romagna

		1993–2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Norway	HA	1660						168	145	176	190	191	181	126	132	130	
	aTSA	89						31	38	57	76	84	64	103	128	144	
	rTSA	301						71	81	108	140	168	239	265	323	377	
	Resurfacing	210						70	55	65	35	29	24	7	11	7	
USA	HA	77,443	14,988	15,298	17,231	17,883	18,052	18,601	20,178	/	/	15,434	/	/	/	/	
	aTSA	66,086	10,192	10,658	15,432	16,811	20,086	23,358	26,773	/	/	29,359	/	/	/	/	
	rTSA									/	/	21,692	/	/	/	/	
Germany	HA					5460	6130	6640	7512	7243	7055	6726	5975				
	aTSA					2321	2911	3628	6788	8426	10,190	11,928	13,329				
	rTSA								2935	3936	5326	6804	8011				
UK	HA												855	1261	1244	1204	927
	aTSA												827	1459	1786	1927	1939
	rTSA												806	1531	2100	2516	3015
Italy	HA	844	/	917	/	1051	/	1203	1234	1242	1333	1211	1352	1432	1281		
	aTSA + rTSA	695	/	934	/	1455	/	2036	2175	2515	2965	3444	3793	4421	5307		
	Total	1539	/	1851	/	2506	/	3239	3409	3757	4298	4655	5145	5853	6588		
Australia	HA												3627	4335	4956	5415	5810
	aTSA												5055	6347	7560	8906	10,230
	rTSA												4010	5530	7416	9682	12,362
	Resurfacing												85	120	157	181	198
Emilia-Romagna	HA								40	127	115	150	142	76	80	49	
	aTSA								15	39	57	2	48	92	67	51	
	rTSA								53	201	224	351	439	429	529	629	
	Resurfacing								6	32	85	49	41	16	4	/	

The number of different shoulder arthroplasty implants is reported for each disposable time interval

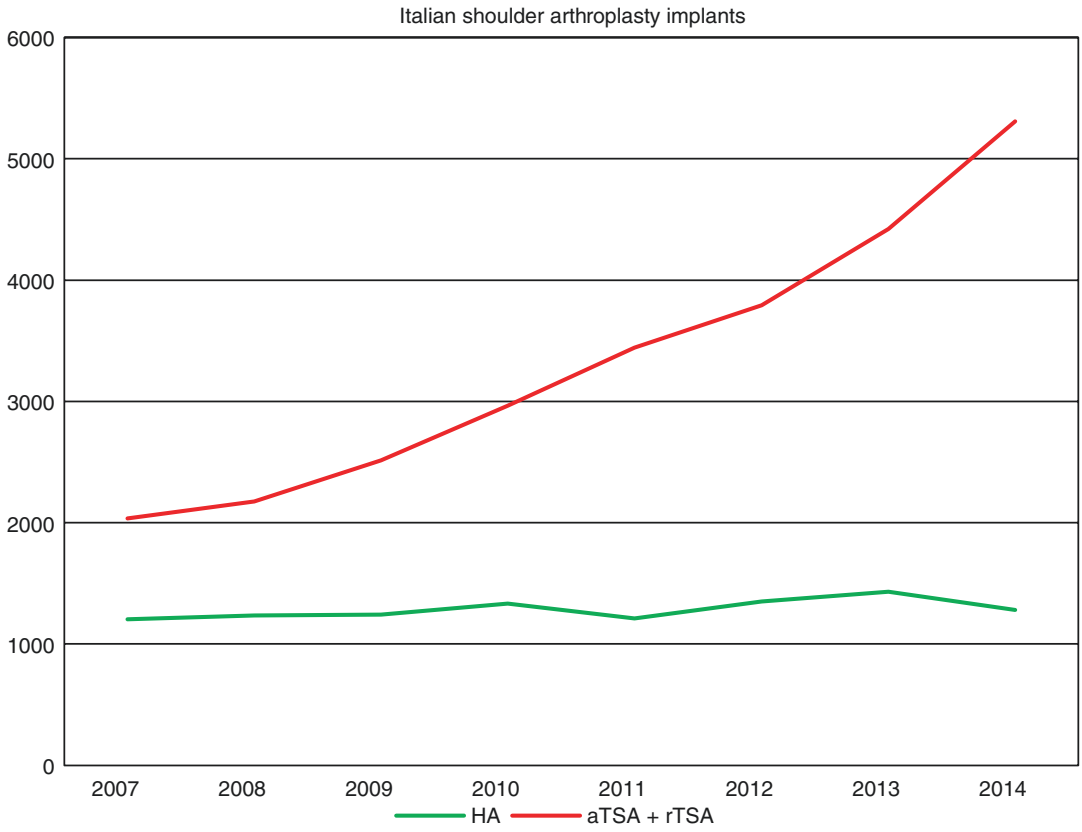

Fig 4.5 Graphic illustrating annual variation in shoulder arthroplasty implant between 2008 and 2015 in Emilia-Romagna (Italy). Data from Emilia-Romagna Register of the Orthopaedic Prosthetic Implants (RIPO)

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