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Endovascular Treatments Performed Collaboratively by the Society of Korean Endovascular Neurosurgeons Members : A Nationwide Multicenter Survey

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Objective : Since less invasive endovascular treatment was introduced to South Korea in 1994, a considerable proportion of endovascular treatments have been performed by neuroradiology doctors, and endovascular treatments by vascular neurosurgeons have recently increased. However, few specific statistics are known regarding how many endovascular treatments are performed by neurosurgeons. Thus, authors compared endovascular treatments collaboratively performed by vascular neurosurgeons with all cases throughout South Korea from 2013 to 2017 to elucidate the role of neurosurgeons in the field of endovascular treatment in South Korea.

Methods : The Society of Korean Endovascular Neurosurgeons (SKEN) has issued annual reports every year since 2014. These reports cover statistics on endovascular treatments collaboratively or individually performed by SKEN members from 2013 to 2017. The data was requested and collected from vascular neurosurgeons in various hospitals. The study involved 77 hospitals in its first year, and 100 in its last. National statistics on endovascular treatment from all over South Korea were obtained from the Healthcare Bigdata Hub website of the Health Insurance Review & Assessment Service based on the Electronic Data Interchange (EDI) codes (in the case of intra-arterial (IA) thrombolysis, however, statistics were based on a combination of the EDI and I63 codes, a cerebral infarction disease code) from 2013 to 2017. These two data sets were directly compared and the ratios were obtained.

Results : Regionally, during the entire study period, endovascular treatments by SKEN members were most common in Gyeonggi-do, followed by Seoul and Busan. Among the endovascular treatments, conventional cerebral angiography was the most common, followed by cerebral aneurysmal coiling, endovascular treatments for ischemic stroke, and finally endovascular treatments for vascular malformation and tumor embolization. The number of endovascular treatments performed by SKEN members increased every year.

Conclusion : The SKEN members have been responsible for the major role of endovascular treatments in South Korea for the recent 5 years. This was achieved through the perseverance of senior members who started out in the midst of hardship, the establishment of standards for the training/certification of endovascular neurosurgery, and the enthusiasm of current SKEN members who followed. To provide better treatment to patients, we will have to make further progress in SKEN.

Key Words : Endovascular procedures · Big data · Data interpretation, Statistical.

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INTRODUCTION

We live in an era of many medical upheavals. For instance, the development of technology and medical knowledge due to material engineering and basic sciences have led to rapid advances in medical equipment. In addition, rapid changes in national medical policies, such as introduction of telemedicine, abolition of uncovered health services or the reduced workload for residents as 80-hour per week, have changed the medical environment[16]. Vascular neurosurgeons must adapt to these changes to stay current. Recently, vascular neurosurgery has become more popular, even though it is perceived as 3D-jobs in the neurosurgical field, because vascular neurosurgeons have begun to perform less invasive endovascular treatment as well as the traditional open surgical treatments. In fact, younger vascular neurosurgeons view endovascular treatment as a necessity, not an option, and so-called "hybrid" vascular neurosurgeons who can perform both craniotomies and endovascular surgery are taken for granted. Relatedly, the residents' training regulations of the Korean Neurosurgical Society have been changed to allow more endovascular treatment in training programs.

Although, a considerable proportion of endovascular treatment in South Korea since 1994 has been carried out by neuroradiology doctors, endovascular treatment performed by vascular neurosurgeons had been increased gradually, and they have increased much more since the establishment of standards for the training and certification of endovascular neurosurgery in South Korea has been firstly published[17]. However, few specific statistics are known regarding how many endovascular treatments are performed by neurosurgeons, so the role of neurosurgeons in this field is unclear. For this reason, the annual reports of the Society of Korean Endovascular Neurosurgeons (SKEN) from 2013 to 2017 have included a statistical report on endovascular treatment performed by or with the participation of vascular neurosurgeons. In the present study, authors compared endovascular treatment cases by vascular neurosurgeons of the SKEN annual reports with data obtained from the nationwide Health Insurance Review and Assessment Service (HIRA) of South Korea from 2013 to 2017. In this way, authors ascertained the pattern of endovascular treatment in South Korea and examined the role of vascular neurosurgeons in the field of endovascular treatment in South Korea.

MATERIALS AND METHODS

Data collection and period in annual report of SKEN from 2013 to 2017

The SKEN has been issuing annual reports since 2014; these include statistics on all endovascular treatments performed alone or collaboratively with another clinician, such as a neuroradiologist, by SKEN members between 2013 and 2017. These data were collected using a data sheet that recorded the number of endovascular treatments performed in each year. Firstly, the editorial director of the annual report notified each hospital via e-mail. The hospitals then sent data via e-mail using the data sheet (Fig. 1). The data were also requested and collected from vascular neurosurgeons of various hospitals, including certified institutions of the SKEN via one-on-one telephone calls and text messages by the editorial director. This data collection was carried out over about 3 months each year from 2014 to 2018. The number of hospitals involved ranged from 77 to 100, and the number of endovascular treat-

Category			Number of case	Total
1. DSA				
2. Cerebral aneurysm	Coiling	Intra-aneurysm		UIA ( ) Ruptured ( )
		PAO (trapping)		
	Stent or ballon assisted coiling			
3. Ischemic stroke	IA thrombolysis for acute stroke			
	Extracranial PTA or stent for extracranial stenosis	CAS (carotid bulb stent)		
		CAS 외		
	Intracranial PTA or stent for intracranial stenosis			
4. Vascular malformations	AVM embo with glue/Onyx			
	Dural AVF and CCF embolization			
5. Tumor embolization				

Fig. 1. Required statistical data sheet delivered to SKEN members. The number of aneurysmal treatments reported in this annual report was counted as the number of aneurysms, which is different from the number in the HIRA, which was counted by patient. SKEN : The Society of Korean Endovascular Neurosurgeons, HIRA : the Health Insurance Review & Assessment Service, DSA : digital subtraction angiography, PAO : parent artery occlusion, UIA : unruptured intracranial aneurysms, PTA : percutaneous transluminal angioplasty, CAS : carotid artery stenting, AVM : arteriovenous malformation, AVF : arteriovenous fistula, CCF : carotid-cavernous fistula.

ments was assumed to be the number of patients, except in the case of aneurysms, whereby the number of aneurysm itself was recorded. In this regard, the report differed from the HIRA, in which the number of patients with aneurysm was counted. This was taken into account during data analysis. The present study analyzed these clinical data from annual SKEN report between 2013 and 2017.

Data collection and period from the Healthcare Bigdata Hub of HIRA

National statistics on endovascular treatment in South Korea were obtained from the Healthcare Bigdata Hub website of the HIRA. The target period for data collection was also 2013–2017. These data were collected in accordance with the Electronic Data Interchange (EDI) code, which was matched to the endovascular treatments on the data sheet distributed to SKEN members (Table 1). However, in the case of intra-arterial (IA) thrombolysis, data collection was based on a combination of the EDI and I63 codes, a cerebral infarction disease code, because the HIRA provided additional data on combining the EDI and I63 codes. We believe that the combined data are more accurate than data from the EDI code only.

Data analysis

This study was approved by the Institutional Review Board (IRB) of CHA Bundang Medical Center, CHA Univeristy School of Medicine on July 4th, 2019 as a deliberative exemption (IRB No. CHAMC 2019-06-035). Authors directly compared the data collected from SKEN with the nationwide data from the Healthcare Bigdata Hub of the HIRA. However, the category of extracranial percutaneous transluminal angioplasty or stent including carotid artery stenting ("EC-PTA or stent [CAS]") and EC-PTA or stent excluding carotid artery stenting ("EC-PTA or stent [the rest of CAS]") in the data collected from SKEN were combined into "EC-PTA or stent (including CAS)" and compared to the "EC-PTA or stent (including CAS)" in HIRA's data. Authors also obtained the ratio between the data collected from SKEN and the nationwide data. Using these data, authors analyzed the flow and trends of endovascular treatments performed in South Korea from 2013 to 2017.

RESULTS

Endovascular treatments performed collaboratively by vascular neurosurgeons from 2013 to 2017

In the years 2013 to 2017, 77, 82, 85, 93, and 100 hospitals participated in the survey, respectively. The data for each hospital were analyzed by region and category, and the overall data were analyzed according to each category (Table 2). Regionally, in all the years analyzed, endovascular treatments were most common in Gyeonggi-do, followed by Seoul and Busan (Fig. 2). With regards to specific endovascular treatments, conventional cerebral angiography was the most common (that is digital subtraction angiography; "DSA"), followed by cerebral aneurysmal coiling and treatments for ischemic stroke, vascular malformation,

Table 1. Endovascular treatments and EDI codes matched

Endovascular treatments	EDI code
DSA	HA 601, HA602, HA603, HA604, HA605, HA606, HA691, HA692, HA693, HA694
Coiling	M1662
Stent or balloon assisted coiling	M1661
IA thrombolysis for cerebral infarction*	M6630, M6631, M6633, M6636 + I63
Extracranial PTA or Stent	M6602, M6594
Intracranial PTA or Stent	M6601, M6593
AVM embolization	M1663, M1667, M1668, M1669
Dural AVF or CCF embolization	M1664, M1665, M1666
Tumor embolization	M1673, M1674, M1675

*Exceptionally, in the case of IA thrombolysis, it was based by combining EDI code and I63, a cerebral infarction disease code. EDI : Electronic Data Interchange, DSA : digital subtraction angiography, IA : intra-arterial, PTA : percutaneous transluminal angioplasty, AVM : arteriovenous malformation, AVF : arteriovenous fistula, CCF : carotid-cavernous fistula

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Table 2. Data from SKEN members according to category from 2013 to 2017

Year	The number of participating hospitals	DSA	Cerebral aneurysm								Ischemic stroke				Vascular malformation		Tumor embolization
			Coiling	PAO	Stent or balloon	Sub total*	UIA	Ruptured	Sub total†	IA thrombolysis for cerebral infarction	EC PTA or stent (CAS)	EC PTA or stent (the rest of CAS)	IC PTA or stent	AVM	Dural AVF or CCF	
2013	77	25889	3275	83	1944	5302	3303	1999	5302	1179	1197	0	422	177	184	295
2014	82	28354	3577	77	2211	5865	3595	2270	5865	1570	1378	194	466	226	170	258
2015	85	33537	4022	107	2481	6610	4233	2377	6610	1738	1425	300	540	246	243	349
2016	93	38860	4513	112	3104	7729	5030	2699	7729	2187	1598	240	532	249	305	427
2017	100	44596	4935	118	3348	8401	5563	2838	8401	2666	1820	226	719	221	276	401
Ratio of 2017/2013	129.9	172.3	150.7	142.2	172.2	158.4	168.4	142.0	158.4	226.1	152	116.5‡	170.4	124.9	150	135.9

*The meaning of this 'subtotal' is the sum of the 'coiling', 'PAO' and 'Stent or balloon'. †The meaning of this 'subtotal' is the sum of the 'UIA' and 'Ruputred'. ‡Ratio of 2014 to 2017. SKEN : The Society of Korean Endovascular Neurosurgeons, DSA : digital subtraction angiography, PAO : parent artery occlusion, UIA : unruptured intracranial aneurysms, IA : intra-arterial, ECPTA : extracranial percutaneous transluminal angioplasty, CAS : carotid artery stenting, ICPTA : intracranial percutaneous transluminal angioplasty, AVM : arteriovenous malformation, AVF : arteriovenous fistula, CCF : carotid-cavernous fistula

and tumor embolization (Fig. 3).

The number of hospitals participating in data collection gradually increased during the study period, as did the number of endovascular treatments performed collaboratively by SKEN members. However, the increase in the

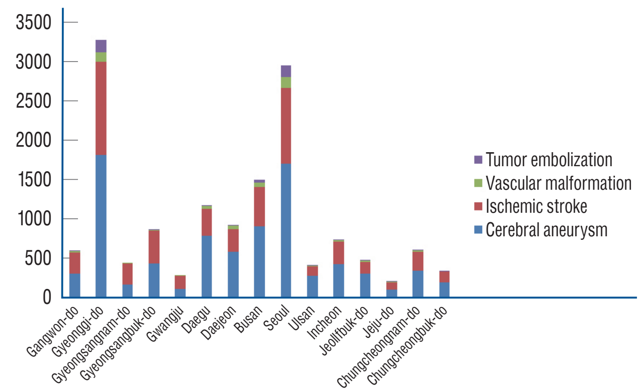

Fig. 2. Graphical data from the SKEN members according to region and category in 2017. Endovascular treatments were the most common in Gyeonggi-do, followed by Seoul and Busan. This trend was also observed in all periods from 2013 to 2017. SKEN : The Society of Korean Endovascular Neurosurgeons.

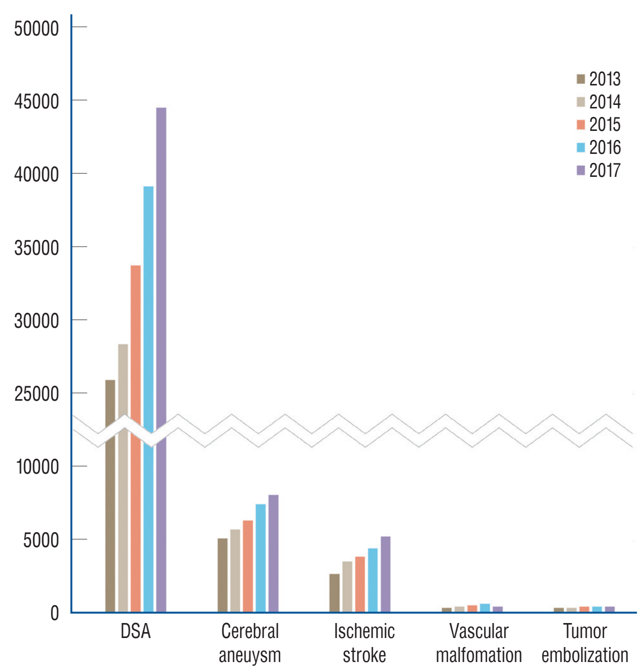

Fig. 3. Serial data from SKEN members according to each category. With the exception of digital subtraction angiography (DSA), cerebral aneurysmal coiling was the most common, endovascular treatments for ischemic stroke were second, followed by endovascular treatments for vascular malformation and tumor embolization. SKEN : The Society of Korean Endovascular Neurosurgeons.

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Table 3. Comparison between data collected from SKEN members and nationwide data from the Healthcare Bigdata Hub of the HIRA from 2013 to 2017

Year	DSA		Cerebral aneurysm				Ischemic stroke						Vascular malformation				Tumor embolization	
			Coiling+PAO		Stent or balloon		IA thrombolysis for cerebral infarction		EC PTA or stent (including CAS)		IC PTA or stent		AVM		Dural AVF or CCF			
	SKEN	HA601-6, HA691-4	SKEN	M1662	SKEN	M1661	SKEN*	M6630, 1,3,6 + I63	SKEN	M6602, M6594	SKEN	M6601, M6593	SKEN	M1663, 7-9	SKEN	M1664 -6	SKEN	M1673-5
2013	25889 (55.6%)	46541	3358 (101.5%)	3307	1944 (60.1%)	3236	1179 (72.8%)	1620	1197 (52.1%)	2297	422 (66.2%)	637	177 (60.8%)	291	184 (76.0%)	242	295 (47.9%)	616
2014	28354 (54.6%)	51975	3654 (98.6%)	3707	2211 (64.9%)	3409	1570 (83.5%)	1880	1572 (66.7%)	2358	466 (72.5%)	643	226 (61.4%)	368	170 (62.7%)	271	258 (41.5%)	622
2015	33537 (49.6%)	67651	4129 (102.0%)	4050	2481 (67.2%)	3691	1738 (69.0%)	2520	1725 (71.0%)	2431	540 (77.1%)	700	246 (70.7%)	348	243 (85.6%)	284	349 (52.8%)	661
2016	38860 (50.5%)	77024	4625 (105.9%)	4369	3104 (66.3%)	4684	2187 (75.1%)	2912	1838 (68.8%)	2672	532 (73.9%)	720	249 (73.9%)	337	305 (95.3%)	320	427 (59.1%)	722
2017	44596 (53.6%)	83268	5053 (108.5%)	4655	3348 (63.7%)	5258	2666 (77.5%)	3442	2046 (69.9%)	2929	719 (87.2%)	825	221 (66.2%)	334	276 (80.5%)	343	401 (45.7%)	878
Ratio of 2017/2013	172.3	178.9	150.5	140.8	172.2	162.5	226.1	212.5	170.9	127.5	170.4	129.5	124.9	114.8	150	141.7	135.9	142.5

*These data from SKEN members may include non-cerebral infarction cases, for example, when IA thrombectomy were performed for the thromboembolism that occurred during any endovascular procedures. SKEN : The Society of Korean Endovascular Neurosurgeons, DSA : digital subtraction angiography, PAO : parent artery occlusion, IA : intra-arterial, EC : extracranial, PTA : percutaneous transluminal angioplasty, CAS : carotid artery stenting, IC : intracranial, AVM : arteriovenous malformation, AVF : arteriovenous fistula, CCF : carotid-cavernous fistula

Table 4. Comparison between data collected from SKEN members and nationwide data from the Healthcare Bigdata Hub of the HIRA in 2013

Category	DSA		Cerebral aneurysm				Ischemic stroke						Vascular malformation				Tumor embolization	
			Coiling+PAO		Stent or balloon		IIA thrombolysis for cerebral infarction		EC PTA or stent (including CAS)		IC PTA or stent		AVM		Dural AVF or CCF			
	SKEN	HA601-6, HA691-4	SKEN	M1662	SKEN	M1661	SKEN	M6630, M6631, M6633, M6636 + I63	SKEN	M6602, M6594	SKEN	M6601, M6593	SKEN	M1663, M1667, M1668, M1669	SKEN	M1664, M1665, M1666	SKEN	M1673, M1674, M1675
Seoul	3270	14448	774	1163	218	833	97	302	164	592	31	171	52	135	55	141	69	366
Busan	3843	4452	377	312	315	385	201	157	164	190	71	60	24	26	24	20	48	45
Incheon	2207	2048	171	156	71	64	83	57	72	85	41	24	9	9	7	0	13	12
Daegu	2922	3152	307	241	184	170	179	200	78	143	14	27	22	20	13	5	3	8
Gwangju	384	1491	91	85	57	56	9	117	26	87	10	38	5	7	3	6	0	0
Daejeon	1450	1927	205	193	122	159	91	81	50	136	31	36	8	9	1	1	1	3
Ulsan	724	791	133	13	69	167	36	26	18	24	8	5	2	3	7	4	2	3
Gyeonggi-do	5351	8463	605	497	446	671	152	213	235	440	70	117	32	44	49	41	133	143
Gangwon-do	660	959	78	62	64	59	54	53	66	85	19	21	4	4	7	4	6	4
Chungcheongbuk-do	974	1272	87	73	70	116	39	60	54	88	8	18	0	3	0	1	0	0
Chungcheongnam-do	509	1225	33	107	61	134	12	22	33	93	33	32	1	5	6	3	3	4
Jeollabuk-do	1264	1854	112	121	81	60	42	150	112	135	35	54	1	2	1	3	8	7
Jeollanam-do	0	109	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyeongsangbuk-do	1571	2258	165	49	61	155	101	71	73	81	25	21	13	16	5	1	1	2
Gyeongsangnam-do	207	1570	170	186	89	180	61	91	31	97	0	6	1	6	5	11	6	17
Jeju-do	553	522	50	49	36	27	22	20	21	21	26	7	3	2	1	1	2	2
Total	25889 (55.6%)	46541	3358 (101.5%)	3307	1944 (60.1%)	3236	1179 (72.8%)	1620	1197 (52.1%)	2297	422 (66.2%)	637	177 (60.8%)	291	184 (76.0%)	242	295 (47.9%)	616

SKEN : The Society of Korean Endovascular Neurosurgeons, HIRA : the Health Insurance Review & Assessment Service, DSA : digital subtraction angiography, PAO : parent artery occlusion, IA : intra-arterial, EC : extracranial, PTA : percutaneous transluminal angioplasty, CAS : carotid artery stenting, AVM : arteriovenous malformation, AVF : arteriovenous fistula, CCF : carotid-cavernous fistula

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Table 5. Comparison between data collected from SKEN members and nationwide data from the Healthcare Bigdata Hub of the HIRA in 2014

Category	DSA		Cerebral aneurysm				Ischemic stroke						Vascular malformation				Tumor embolization	
			Coiling+PAO		Stent or balloon		IA thrombolysis for cerebral infarction		EC PTA or stent (including CAS)		IC PTA or stent		AVM		Dural AVF or CCF			
	SKEN	HA601-6, HA691-4	SKEN	M1662	SKEN	M1661	SKEN	M6630, M6631, M6633, M6636 + I63	SKEN	M6602, M6594	SKEN	M6601, M6593	SKEN	M1663, M1667, M1668, M1669	SKEN	M1664, M1665, M1666	SKEN	M1673, M1674, M1675
Seoul	3446	15556	733	1218	256	825	142	296	177	540	23	127	35	161	40	130	71	390
Busan	4082	5031	478	346	386	462	263	208	224	253	52	60	40	30	28	25	26	38
Incheon	1922	2276	203	186	70	74	113	64	60	64	42	21	16	16	8	5	6	7
Daegu	3117	3516	346	301	222	247	180	258	86	136	17	20	33	31	11	10	4	7
Gwangju	300	1556	68	60	82	77	20	106	20	74	3	33	2	3	0	9	0	0
Daejeon	1985	2227	337	277	150	151	102	95	127	165	38	35	16	15	12	11	18	18
Ulsan	756	933	75	33	33	120	34	31	10	19	10	7	9	11	4	7	3	7
Gyeonggi-do	6593	10150	658	582	548	771	222	314	368	462	156	157	49	57	46	54	111	128
Gangwon-do	764	1124	109	96	57	56	43	33	85	75	37	36	9	8	3	2	1	2
Chungcheongbuk-do	504	1005	58	50	37	98	23	45	28	53	1	12	0	4	0	0	0	2
Chungcheongnam-do	731	1430	119	116	127	172	33	29	75	109	15	23	5	13	8	4	3	4
Jeollabuk-do	1249	1798	112	133	96	40	136	161	146	165	33	40	1	2	3	5	8	10
Jeollanam-do	0	302	0	1	0	4	0	22	0	12	0	11	0	0	0	0	0	0
Gyeongsangbuk-do	2209	2843	182	75	58	139	112	80	96	92	31	27	5	7	3	1	2	1
Gyeongsangnam-do	356	1575	123	176	60	151	86	102	40	99	1	10	3	8	2	6	3	5
Jeju-do	340	653	53	57	29	22	61	36	30	40	7	24	3	2	2	2	2	3
Total	28354 (54.6%)	51975	3654 (98.6%)	3707	2211 (64.9%)	3409	1570 (83.5%)	1880	1572 (66.7%)	2358	466 (72.5%)	643	226 (61.4%)	368	170 (62.7%)	271	258 (41.5%)	622

SKEN : The Society of Korean Endovascular Neurosurgeons, HIRA : the Health Insurance Review & Assessment Service, DSA : digital subtraction angiography, PAO : parent artery occlusion, IA : intra-arterial, EC : extracranial, PTA : percutaneous transluminal angioplasty, CAS : carotid artery stenting, AVM : arteriovenous malformation, AVF : arteriovenous fistula, CCF : carotid-cavernous fistula

Table 6. Comparison between data collected from SKEN members and nationwide data from the Healthcare Bigdata Hub of the HIRA in 2015

Category	DSA		Cerebral aneurysm				Ischemic stroke						Vascular malformation				Tumor embolization	
			Coiling+PAO		Stent or balloon		IA thrombolysis for cerebral infarction		EC PTA or stent (including CAS)		IC PTA or stent		AVM		Dural AVF or CCF			
	SKEN	HA601-6, HA691-4	SKEN	M1662	SKEN	M1661	SKEN	M6630, M6631, M6633, M6636 + I63	SKEN	M6602, M6594	SKEN	M6601, M6593	SKEN	M1663, M1667, M1668, M1669	SKEN	M1664, M1665, M1666	SKEN	M1673, M1674, M1675
Seoul	6046	19383	852	1180	421	948	238	445	379	624	61	157	92	171	95	133	108	394
Busan	4462	6629	508	393	387	468	239	228	186	226	51	50	45	21	21	26	51	28
Incheon	1789	2693	254	236	69	66	83	95	42	64	15	18	9	12	6	3	9	7
Daegu	2201	4163	262	304	157	193	106	267	65	132	10	20	9	23	9	11	1	12
Gwangju	643	1915	77	68	54	52	30	123	14	49	2	16	2	7	10	14	3	1
Daejeon	2245	2924	368	295	176	179	114	97	109	120	37	39	12	12	12	7	10	14
Ulsan	767	1545	131	69	51	151	44	58	17	23	13	21	2	3	3	5	2	20
Gyeonggi-do	8447	13818	759	675	679	922	329	471	417	548	158	150	52	59	47	51	124	132
Gangwon-do	963	1709	153	131	65	69	62	52	111	90	43	56	5	6	8	6	3	2
Chungcheongbuk-do	432	1815	72	83	41	73	43	94	44	64	4	26	0	2	1	0	0	5
Chungcheongnam-do	769	1874	107	113	109	155	32	44	68	129	22	25	6	12	8	5	10	13
Jeollabuk-do	1151	2067	146	151	72	39	49	175	97	137	37	46	5	6	16	11	9	9
Jeollanam-do	0	543	0	11	0	12	0	23	0	21	0	8	0	0	0	0	0	1
Gyeongsangbuk-do	2222	3798	250	128	66	164	144	140	99	91	29	35	3	4	2	1	3	3
Gyeongsangnam-do	926	2004	118	152	106	180	162	171	62	88	42	16	1	10	3	9	5	13
Jeju-do	474	771	72	61	28	20	63	37	15	25	16	17	3	0	2	2	11	7
Total	33537 (49.6%)	67651	4129 (102.0%)	4050	2481 (67.2%)	3691	1738 (69.0%)	2520	1725 (71.0%)	2431	540 (77.1%)	700	246 (70.7%)	348	243 (85.6%)	284	349 (52.8%)	661

SKEN : The Society of Korean Endovascular Neurosurgeons, HIRA : the Health Insurance Review & Assessment Service, DSA : digital subtraction angiography, PAO : parent artery occlusion, IA : intra-arterial, EC : extracranial, PTA : percutaneous transluminal angioplasty, CAS : carotid artery stenting, AVM : arteriovenous malformation, AVF : arteriovenous fistula, CCF : carotid-cavernous fistula

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Table 7. Comparison between data collected from SKEN members and nationwide data from the Healthcare Bigdata Hub of the HIRA in 2016

Category	DSA		Cerebral aneurysm				Ischemic stroke						Vascular malformation				Tumor embolization	
			Coiling+PAO		Stent or balloon		IA thrombolysis for cerebral infarction		EC PTA or stent (including CAS)		IC PTA or stent		AVM		Dural AVF or CCF			
	SKEN	HA601-6, HA691-4	SKEN	M1662	SKEN	M1661	SKEN	M6630, M6631, M6633, M6636 + I63	SKEN	M6602, M6594	SKEN	M6601, M6593	SKEN	M1663, M1667, M1668, M1669	SKEN	M1664, M1665, M1666	SKEN	M1673, M1674, M1675
Seoul	8380	21915	1055	1266	570	1273	327	502	397	609	85	150	92	167	139	157	168	439
Busan	4602	7074	548	464	485	529	243	231	211	226	35	36	38	26	27	24	47	49
Incheon	2015	2998	249	261	81	71	136	144	67	95	11	13	6	5	5	6	7	10
Daegu	3894	4983	370	330	245	228	260	285	79	137	18	12	12	20	13	13	4	14
Gwangju	488	2120	63	63	55	57	51	142	26	88	2	25	5	8	8	12	2	1
Daejeon	2061	3305	309	221	166	274	124	115	96	157	35	42	19	22	9	5	10	10
Ulsan	283	1936	101	91	66	198	35	52	17	41	12	11	7	10	3	7	5	12
Gyeonggi-do	8579	15140	938	726	834	1076	375	559	455	534	152	183	43	48	61	54	154	139
Gangwon-do	1514	2042	162	144	89	79	93	80	110	85	51	60	7	11	14	8	9	2
Chungcheongbuk-do	615	2165	85	106	45	114	30	86	48	87	13	27	0	3	1	3	1	2
Chungcheongnam-do	1005	2495	123	134	158	228	58	79	65	174	32	41	9	4	10	9	7	6
Jeollabuk-do	1317	2548	179	209	119	55	68	151	96	150	22	46	7	2	10	4	3	8
Jeollanam-do	0	784	0	10	0	18	0	71	0	44	0	10	0	0	0	0	0	0
Gyeongsangbuk-do	2669	4068	292	159	83	186	152	137	83	83	29	31	3	4	2	2	4	3
Gyeongsangnam-do	827	2717	79	123	87	273	182	236	58	131	33	22	0	6	3	16	1	19
Jeju-do	611	734	72	62	21	25	53	42	30	31	2	11	1	1	0	0	5	8
Total	38860 (50.5%)	77024	4625 (105.9%)	4369	3104 (66.3%)	4684	2187 (75.1%)	2912	1838 (68.8%)	2672	532 (73.9%)	720	249 (73.9%)	337	305 (95.3%)	320	427 (59.1%)	722

SKEN : The Society of Korean Endovascular Neurosurgeons, HIRA : the Health Insurance Review & Assessment Service, DSA : digital subtraction angiography, PAO : parent artery occlusion, IA : intra-arterial, EC : extracranial, PTA : percutaneous transluminal angioplasty, CAS : carotid artery stenting, AVM : arteriovenous malformation, AVF : arteriovenous fistula, CCF : carotid-cavernous fistula

Table 8. Comparison between data collected from SKEN members and nationwide data from the Healthcare Bigdata Hub of the HIRA in 2017

Category	DSA		Cerebral aneurysm				Ischemic stroke						Vascular malformation				Tumor embolization	
			Coiling+PAO		Stent or balloon		IA thrombolysis for cerebral infarction		EC PTA or stent (including CAS)		IC PTA or stent		AVM		Dural AVF or CCF			
	SKEN	HA601-6, HA691-4	SKEN	M1662	SKEN	M1661	SKEN	M6630, M6631, M6633, M6636 + I63	SKEN	M6602, M6594	SKEN	M6601, M6593	SKEN	M1663, M1667, M1668, M1669	SKEN	M1664, M1665, M1666	SKEN	M1673, M1674, M1675
Seoul	8964	24477	1162	1392	537	1468	434	642	427	667	103	195	50	142	91	165	147	531
Busan	5310	7326	482	478	418	566	250	282	214	250	43	48	21	24	32	30	38	49
Incheon	2470	3525	314	272	107	114	161	158	102	125	28	30	5	6	10	7	2	8
Daegu	4012	4565	501	391	279	300	250	263	82	147	16	28	13	24	20	13	4	2
Gwangju	412	2358	56	55	53	48	82	196	41	114	40	22	10	9	1	9	0	0
Daejeon	2632	3345	340	204	243	296	147	130	102	141	37	32	25	20	17	11	8	8
Ulsan	839	2258	129	82	142	227	67	75	32	41	19	15	10	13	6	3	9	15
Gyeonggi-do	10667	17000	958	741	857	1162	507	658	485	607	195	180	45	45	70	62	161	213
Gangwon-do	1869	2286	192	171	108	97	127	114	101	91	39	38	10	12	7	4	6	1
Chungcheongbuk-do	501	2145	79	121	111	142	37	116	73	114	28	42	2	4	0	6	1	3
Chungcheongnam-do	1602	2576	166	152	175	213	73	74	123	147	41	48	8	10	7	4	12	12
Jeollabuk-do	1088	2508	196	201	109	74	42	165	53	179	50	37	7	6	6	7	2	5
Jeollanam-do	0	700	0	19	0	26	0	70	0	37	0	8	0	0	0	2	0	0
Gyeongsangbuk-do	2957	4347	311	158	116	213	238	192	140	126	44	47	9	7	2	1	7	5
Gyeongsangnam-do	726	3193	94	148	65	282	197	262	48	118	24	38	2	9	7	15	0	14
Jeju-do	547	659	73	70	28	30	54	45	23	25	12	17	4	3	0	4	4	12
Total	44596 (53.6%)	83268	5053 (108.5%)	4655	3348 (63.7%)	5258	2666 (77.5%)	3442	2046 (69.9%)	2929	719 (87.2%)	825	221 (66.2%)	334	276 (80.5%)	343	401 (45.7%)	878

SKEN : The Society of Korean Endovascular Neurosurgeons, HIRA : the Health Insurance Review & Assessment Service, DSA : digital subtraction angiography, PAO : parent artery occlusion, IA : intra-arterial, EC : extracranial, PTA : percutaneous transluminal angioplasty, CAS : carotid artery stenting, AVM : arteriovenous malformation, AVF : arteriovenous fistula, CCF : carotid-cavernous fistula

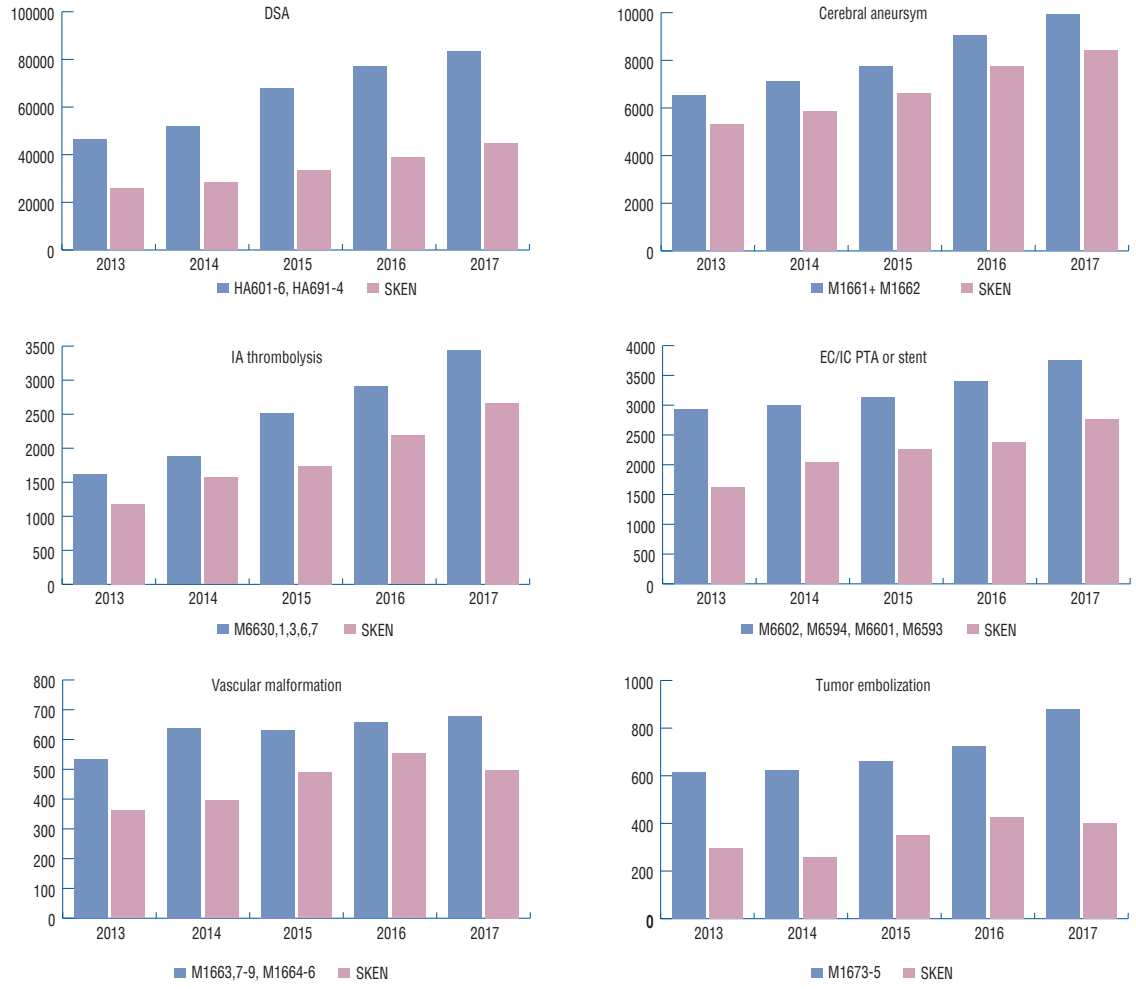

Fig. 4. Comparison between data collected from SKEN members and nationwide data from the Healthcare Bigdata Hub of the HIRA from 2013 to 2017. SKEN : The Society of Korean Endovascular Neurosurgeons, HIRA : the Health Insurance Review & Assessment Service.

number of endovascular treatments was greater than the increase in the number of participating hospitals. Specifically, the rate of increase in each category was higher than the rate of increase in the number of participating hospitals (from 77 to 100; 29.9%), with the exception of "EC-PTA or stent (the rest of CAS)", which increased from 194 to 226 patients (16.5%), and treatment for arteriovenous malformation ("AVM"), which increased from 177 to 221 patients (24.9%) (Table 2). The rates of increase exceeded 50% in "DSA", simple coilings ("coiling"), stent- or balloon-assisted coilings ("stent or balloon"), "IA thrombolysis for cerebral infarction", "EC-PTA or stent (CAS)", "intracranial (IC)-PTA or stent" and dural arteriovenous fistula or carotid-cavernous fistula ("dural AVF or CCF"), especially in the case of "IA thrombolysis for cerebral infarction", which showed an increase of more than 200% (Table 2). The increase in the number of unruptured intracranial aneurysms ("UIA", from 3303 to 5563; 68.4%) was higher than the increase in the number of ruptured aneurysms ("Ruptured", from 1999 to 2838; 42%).

Nationwide data from the Healthcare Bigdata Hub of the HIRA from 2013 to 2017

Nationwide data from the HIRA between 2013 and 2017 were analyzed by region and category, and the overall data were analyzed according to each category (Tables 3-8). Regionally, endovascular treatment was the most common in Seoul, followed by Gyeonggi-do and Busan in all years ana-

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lyzed. Concerning specific endovascular treatments, "DSA" was the most common, followed by cerebral aneurysmal coiling and treatments for ischemic stroke, vascular malformation, and tumor embolization.

Additionally, national data showed an overall increase in the number of endovascular treatments during the study period, and the rates of increase exceeded 50% in "DSA", aneurysm ("coiling + parent artery occlusion ["PAO"]" and "stent or balloon"), and "IA thrombolysis for cerebral infarction"; "IA thrombolysis for cerebral infarction" showed an increase of more than 200% (Table 3). The rates of increase were about 40% in "dural AVF or CCF" and "tumor embolization", about 30% in "EC-PTA or stent (including CAS)" and intracranial percutaneous transluminal angioplasty or stent ("IC-PTA or stent"), and about 15% in "AVM".

Comparison between data collected from SKEN members and nationwide data from the Healthcare Bigdata Hub of the HIRA from 2013 to 2017

During the 5 years from 2013 to 2017, SKEN members participated in 50–55% of "DSA", 70–80% of "IA thrombolysis for cerebral infarction", 50–70% of "EC-PTA or stent (including CAS)", 65–85% of "IC-PTA or stent", 60–75% of "AVM", 75–95% of "dural AVF or CCF", 40–60% of "tumor embolization" (Tables 3-8; Fig. 4). Although the overall number of endovascular treatments performed by SKEN members increased during the study period, there were no significant changes in the categories "DSA", "IA thrombolysis for cerebral infarction", "AVM", "dural AVF or CCF", and "tumor embolization" with regard to the ratio of data from SKEN members to those from HIRA. An increase in the ratio was observed for "EC-PTA or stent (including CAS)" and "IC-PTA or stent" (Tables 3-8). In the category of aneurysm treatments, SKEN members participated in approximately 100–108% of "coiling" and about 60–65% of "stent or balloon" (Tables 3-8). Because the number of aneurysmal treatments involving SKEN members was counted as the number of aneurysms, while the number of aneurysmal treatments in the HIRA was counted as the number of patients, authors could not directly compare the two data sets, so the derived ratios cannot be meaningful (100–108% and 60–65%). During the 5-year study period, there were no significant changes in the ratio of aneurysmal data between SKEN members and the HIRA (Tables 3-8).

In summary, the ratio of data from SKEN members to that from HIRA was about 50–70% for "DSA", aneurysm ("coiling + PAO" and "stent or balloon"), and "AVM", 70–90% for "IA thrombolysis for cerebral infarction" and "dural AVF or CCF", and 45–60% for "tumor embolization"; these ratios did not change much over the 5-year study period. For "EC-PTA or stent (including CAS)" and "IC-PTA or stent", the ratios were 50–70% and 65–85%, respectively, and the increasing trend was significant.

DISCUSSION

Clinical and autopsy studies suggest that intracranial aneurysms have a frequency of 1–8%[9], and that the incidence of subarachnoid hemorrhage due to ruptured aneurysms ranges from 6 to 8 people per 100,000 in western populations[5]. In the 1960s, McKissock et al.[6-8] were the first to report some controlled trials into the conservative and surgical treatment of ruptured aneurysms. They showed better outcomes using surgical management[6-8]. Since then, surgical techniques, instruments, and management methods have developed greatly, resulting in better outcomes. In 1991, electrolytically detachable coils (Guglielmi detachable coils; Boston scientific/Target Therapeutics, Freemont, CA, USA) were introduced to treat ruptured aneurysms using an endovascular approach. They were approved by United States Food and Drugs Administration (FDA) in 1995[4]. Since then, endovascular coiling has widely been used to treat ruptured and unruptured aneurysms[1,2,15]. In particular, the serial trial known as the International Subarachnoid Aneurysm Trial, which was carried out from 2002 to 2015, proved the efficacy and safety of endovascular coiling methods[11-14]. With these successful trials, endovascular coiling could be recommended in the 2012 guidelines as a first option to treat patients with ruptured aneurysms judged to be technically amenable to both endovascular coiling and neurosurgical clipping[3]. In unruptured aneurysms, endovascular coiling is associated with lower procedural morbidity and mortality than surgical clipping in selected cases, and it is recommended at Class IIa with Level of Evidence B[18].

In South Korea, endovascular treatment research meetings began in 1994. In particular, two meetings were started by neurosurgeons and neuroradiologists, respectively. Each meeting then developed into a society : the SKEN, as well as the Korean Society of Interventional Neuroradiology (KSIN).

At first, endovascular treatments were mainly performed by neuroradiologists. However, many vascular neurosurgeons eventually became interested and involved in endovascular treatment. Recently, endovascular treatment has been performed by neurosurgeons, neuroradiology doctors, or both, and the specific situations vary among hospitals.

According to data collected from SKEN members over 5 years from 2013 to 2017, the number of endovascular treatments performed collaboratively by SKEN members continuously increased over the period. Big cities such as Gyeonggi-do, Seoul, and Busan led this, but the phenomenon was observed nationwide. Among the endovascular treatments, conventional cerebral angiography was the most common, followed by cerebral aneurysmal coiling, endovascular treatments for ischemic stroke, and finally endovascular treatments for vascular malformation and tumor embolization. With the number of hospitals participating in data collection increasing year by year, it was natural that the total number of endovascular treatments performed would increase (Fig. 3). However, the rate of increase in endovascular treatments was higher than that participating hospitals; even when each category was analyzed separately, the rate of increase was higher in all categories of endovascular treatment than in the number of participating hospitals, except for the categories of "EC-PTA or stent(the rest of CAS)", and "AVM" (Table 2). In several categories, the rate showed an increase of more than 50%, and in the "IA thrombolysis for cerebral infarction" category it showed an increase of more than 200% (Table 3). This shows that the number of endovascular treatments performed by SKEN members has increased, although this may have been due to the increase in hospital participation in some cases.

According to data collected from SKEN members, the "EC-PTA or stent(the rest of CAS)" category likely showed a lower rate of increase because this category lies outside the traditional remit of neurosurgery, and the absolute case number of such procedures was small. Authors expect that there will be little future change in this category of "EC-PTA or stent". In the category of "AVM", it is likely that trial known as "A Randomized trial of Unruptured Brain Arteriovenous Malformations" (ARUBA) released in 2014 was the cause of the lower rate of increase. In the ARUBA trial, medical management alone was superior to medical management with interventional therapy in the prevention of death or stroke in patients with unruptured brain AVMs[10]. Therefore, endovascular treatment for unruptured AVM was probably reduced. Unless other studies contradict the results of the ARUBA trail, there may be no change in the rate of increase in the "AVM" category. In the category of aneurysms, there was a higher rate of increase in the number of unruptured aneurysm than in the number of ruptured aneurysms, perhaps because diagnostic tools such as brain computed tomography angiography or magnetic resonance angiography have been developed, or because health screening has been applied nationwide.

According to national data from HIRA from 2013 to 2017, the number of endovascular treatments continuously increased over the 5-year period and were the highest in Seoul, followed by Gyeonggi-do and Busan, which is slightly different from the trend for SKEN data, according to which endovascular treatments were most common in Gyeonggi-do (Tables 3-8). During the study period, the rate of increase in endovascular treatments exceeded 50% in "DSA", aneurysm ("coiling + PAO" and "stent or balloon") and "IA thrombolysis for cerebral infarction", was about 40% in "dural AVF or CCF" and "tumor embolization", and was about 15% in "AVM", which were similar to the results from SKEN data (Table 3). In contrast, the rate of increase was about 30% in "EC-PTA or stent (including CAS)" and "IC-PTA or stent", which was different from the results from SKEN data, according to which the rate of increase was about 70% (Table 3). These results are consistent with the following analysis from a different point of view. Compared with the national data collected from HIRA, there were no significant changes in the ratio of data from SKEN members to data from HIRA in "DSA", aneurysm ("coiling + PAO" and "stent or balloon"), "IA thrombolysis for cerebral infarction", "AVM", "dural AVF or CCF" and "tumor embolization", however, an increase in the ratio was noted for "EC-PTA or stent (including CAS)" and "IC-PTA or stent" (Table 3).

The categories of "DSA" and aneurysm ("coiling" + "PAO" and "stent or balloon") showed a 50–60% ratio for data from SKEN members and from HIRA and "IA thrombolysis for cerebral infarction" showed a 70–80% ratio, which did not change significantly and the rates of increase exceeded 50% during the 5-year study period (Table 3). The reasons might be as follows. Diseases belonging to these categories are representative ones that require endovascular treatment and are quite common, so many of these categories have already been performed by vascular neurosurgeons since 2013. Therefore, this

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Table 9. The list of the hospitals participated in the 2018 survey

Hospital	Regions
Gachon University Gill Medical Center	Incheon
Catholic Kwandong University International St. Mary's Hospital	Incheon
The Catholic University of Korea Daejeon St. Mary's Hospital	Daejeon
The Catholic University of Korea Bucheon St. Mary's Hospital	Gyeonggi-do
The Catholic University of Korea Seoul St. Mary's Hospital	Seoul
The Catholic University of Korea St. Vincent's Hospital	Gyeonggi-do
The Catholic University of Korea Uijeongbu St. Mary's Hospital	Gyeonggi-do
The Catholic University of Korea Incheon St. Mary's Hospital	Incheon
Kyung Hee University Hospital at Gangdong	Seoul
Ulsan University Gangneung Asan Hospital	Gangwon-do
Kangwon National University Hospital	Gangwon-do
Konkuk University Hospital	Chungcheongbuk-do
Konyang University Hospital	Daejeon
Gumdan Top General Hospital	Incheon
Kyungpook National University Hospital	Daegu
Gyeongsang National University Hospital	Gyeongsangnam-do
Kyunghee National University Hospital	Seoul
Kyunghee University Medical Center E&C Jungang General Hospital	Gyeongsangnam-do
Keimyung University Dongsan Medical Center	Daegu
Korea University Ansan Hospital	Gyeonggi-do
Kosin University Gospel Hospital	Busan
National Medical Center	Seoul
Bongseng Memorial Hospital	Busan
Namyangju Hanyang General Hospital	Gyeonggi-do
New Korea Hospital	Gyeonggi-do
Dankook University Hospital	Chungcheongnam-do
Daegu Catholic University Medical Center	Daegu
Daegu Fatima Hospital	Daegu
Sun Medical Center	Daejeon
Daejeon Hankook Hospital	Daejeon
Dongkang Medical Center	Ulsan
Dongguk University Gyeongju Hospital	Gyeongsangbuk-do
Dongguk University Ilsan Hospital	Gyeonggi
Donggunsan General Hospital	Jeollabuk-do

Table 9. Continued

Hospital	Regions
Dongrae-Bongseng Hospital	Busan
Dong-A University Hospital	Busan
Dong-Eui Medical Center	Busan
Mediplex Sejong Hospital	Gyeonggi-do
Myongji Hospital	Gyeonggi-do
Myongji St. Mary's Hospital	Seoul
Pusan National University Hospital	Busan
Seoul National University Bundang Hospital	Gyeonggi-do
Bundang Jesaeng Hospital	Gyeonggi-do
Seodaegu Hospital	Daegu
Ulsan University Asan Medical Center	Seoul
Seoul Medical Center	Seoul
SMG-SNU Boramae Medical Center	Seoul
Kangbuk Samsung Hospital	Seoul
Sungkyunkwan University Samsung Changwon Hospital	Gyeongsangnam-do
Pohang Semyoung Christian Hospital	Gyeongsangbuk-do
Soon Chun Hyang University Hospital Gumi	Gyeongsangbuk-do
Soon Chun Hyang University Hospital Bucheon	Gyeonggi-do
Soon Chun Hyang University Hospital Seoul	Seoul
Soon Chun Hyang University Hospital Cheonan	Chungcheongnam-do
Asan Chungmu Hospital	Chungcheongnam-do
Ajou University Hospital	Gyeonggi-do
Andong Medical Group Hospital	Gyeongsangbuk-do
Andong Sungso Hospital	Gyeongsangbuk-do
Pohang Stroke and Spine Hospital	Gyeongsangbuk-do
Yonsei University Gangnam Severance Hospital	Seoul
Yonsei University Severance Hospital	Seoul
Wonju Severance Christian Hospital	Gangwon-do
Yeungnam University Medical Center	Daegu
Presbyterian Medical Center	Jeollabuk-do
On Hospital	Busan
Ulsan University Ulsan Hospital	Ulsan
Wonkwang University Hospital	Jeollabuk-do
Sun Medical Center	Daejeon
Eulji University Nowon Eulji Medical Center	Seoul
Eulji University Daejeon Eulji Medical Center	Daejeon
Ewha Womans University Mokdong Hospital	Seoul
Hallym Hospital	Incheon

Table 9. Continued

Hospital	Regions
Inje University Seoul Paik Hospital	Seoul
Inje University Haeundae Paik Hospital	Busan
Inha University Hospital	Incheon
Chonnam National University Hospital	Gwangju
Chonbuk National University Hospital	Jeollabuk-do
Jeju National University Hospital	Jeju
Cheju Halla General Hospital	Jeju
Chosun University Hospital	Gwangju
Chung-Ang University Hospital	Seoul
VHS Medical Center	Seoul
CHA University Kumi Medical Center	Gyeongsangbuk-do
CHA University Bundang Medical Center	Gyeonggi-do
Chamjoeun Hospital	Gyeonggi-do
Cheonan Chungmu Hospital	Chungcheongnam-do
Cheongju St. Mary's Hospital	Chungcheongbuk-do
Hankook General Hospital	Chungcheongbuk-do
Chungnam National University Hospital	Daejeon
Pohang St. Mary's Hospital	Gyeongsangbuk-do
Hallym University Kangnam Sacred Heart Hospital	Seoul
Hallym University Kangdong Sacred Heart Hospital	Seoul
Hallym University Dongtan Sacred Heart Hospital	Gyeonggi-do
Hallym University Chuncheon Sacred Heart Hospital	Gangwon-do
Hallym University Medical Center	Gyeonggi-di
Hallym University Hangang Sacred Heart Hospital	Seoul
Hanyang University Guri Hospital	Gyeonggi-do
Hanyang University Seoul Hospital	Seoul
Hongik Hospital	Seoul
Hyosung Hospital	Chungcheongbuk-do

ratio is expected to proceed in a similar trend into the future. And in the category of aneurysmal treatments, the ratio in "coiling" was more than 100%, while in the "stent or balloon" it was 60–65%. The number of aneurysmal treatments involving SKEN members was counted as the number of aneurysms, while the number in the HIRA was counted as the number of patients. Therefore, it was not possible to directly compare the two data sets. However, assuming that multiple aneurysms occur in 25% of cases, SKEN members likely participated in the treatment of more than 50% of aneurysms. In addition, even though the ratio itself was meaningless, there were no significant changes in the ratio of aneurysmal data between SKEN members and the HIRA over the 5-year study period, which may indicate that the data collected by the SKEN were quite reliable. In the category of "IA thrombolysis for cerebral infarction", the rates of increase was above 200%, which was from that the treatment performance improved greatly due to the rapid development of treatment technology in recent years (Table 3). Therefore, the ratio of data from SKEN members to those from HIRA will be similar, but the total number will continue to increase.

"AVM" showed a 60–75% ratio, which did not change significantly during the study period. The rate of increase was about 15–25% during the study period, which was assumed to remain unchanged per the ARUBA trial, as mentioned above. The categories "dural AVF or CCF" and "tumor embolization" showed 75–95% and 40–60% ratios, which did not change significantly over the 5-year study period. The rate of increase was about 40–50% and 36–40%, respectively. Although these categories are not common, they are likely of interest to vascular neurosurgeons. The categories "EC-PTA or stent (including CAS)" and "IC-PTA or stent" showed 50–70% and 65–85% ratios, respectively, and the difference in the rate of increase between SKEN members and HIRA was found to be 30–70%. These ratios seem to change from conventional surgical (in the case of "EC-PTA or stent [including CAS])" or medical (in the case of "IC-PTA or stent") treatment to endovascular treatment, possibly led by vascular neurosurgeons (SKEN members).

In 1997, Veith[19], the President of the Society for Vascular Surgery, delivered the Presidential address in celebration of the 50th anniversary of the foundation of the Society. In that speech, he mentioned the threats to the specialized field of vascular surgery, emphasizing that advances in technology have allowed less-invasive, more cost-effective treatments, and that fiscal policy has encouraged it. This has increased the possibility that vascular surgery will become extinct. The less-invasive treatments of vascular disease he mentioned were endovascular treatments such as catheter-guidewire-imaging techniques involving catheters, balloons, atherectomy devices, stents, stented grafts, etc. He thought these were threats to the vascular surgeons because they confer similar or better results

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to open surgical treatments, and because they can be performed by non-surgical interventional specialists with training in radiology or cardiology[19]. For this reason, he argued that vascular surgeons must learn and practice endovascular treatment skills, and that, if they do not, they will be culled.

This was the situation in the US vascular surgery (not vascular neurosurgery) around 1997, and it is surprisingly similar to the situation of vascular neurosurgery in South Korea since 1994. At that time, endovascular treatment began in South Korea, but no one could be sure about the potential of the treatment for development. Fortunately, our forerunners had foresight and tried to adapt to these changes in the environment. Since 1994, they have established a research meeting and developed it into a society (SKEN) to continue and expand the role of vascular neurosurgeons. Of course, this development process produced many difficulties. While conventional open surgery was already established, endovascular treatment was a field in which results had to be made: there were many trials and errors, and it was difficult to be recognized by the Korean Neurosurgical Society. Furthermore, there were many conflicts with neuroradiologists, who had already taken an important positions in the field of endovascular treatment. Despite these difficulties, our forerunners did not stop their efforts. As the result, a substantial proportion of endovascular treatment in South Korea is now carried out by vascular neurosurgeons, as shown above. The SKEN, which has grown in quantity and quality, still makes such efforts and will continue to do so.

Limitations of the study

The data from the present study were collected from vascular neurosurgeons across the country over 5 years, with 77–100 hospitals involved (Table 9). However, this number does not include all hospitals with vascular neurosurgeons. In other words, the data in this study reflect only a subsection of all vascular neurosurgeons in South Korea. As mentioned earlier, aneurysm cases collected by the SKEN were based on the number of treated aneurysms, while the cases in the HIRA were based on the number of patients. Therefore, it was not possible to directly compare them. If comparisons were made using the same criteria, more accurate results could be obtained.

CONCLUSION

The SKEN members have been responsible for the major role of endovascular treatments in South Korea for the recent 5 years. This was achieved through the perseverance of senior members who started out in the midst of hardship, the establishment of standards for the training/certification of endovascular neurosurgery, and the enthusiasm of current SKEN members who followed. To provide better treatment to patients, we will have to make further progress in SKEN.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

INFORMED CONSENT

This type of study does not require informed consent.

AUTHOR CONTRIBUTIONS

Conceptualization : BTK
Data curation : TGK, OKK, YSS, JHS, JSK, BTK
Formal analysis : TGK
Funding acquisition : TGK, BTK
Methodology : TGK, BTK
Project administration : BTK
Visualization : TGK
Writing - original draft : TGK
Writing - review & editing : BTK

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