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What is the Utility Of a Limb Lengthening and Reconstruction Service in an Academic Department of Orthopaedic Surgery?

S. Robert Rozbruch MD, Elizabeth S. Rozbruch, Samuel Zonshayn BS, Eugene W. Borst BS, Austin T. Fragomen MD

Abstract

Background Limb lengthening and reconstruction surgery is a relatively new subspecialty of orthopaedic surgery in the United States. Despite increased awareness and practice of the specialty, it is rarely vested as a separate clinical service in an academic department of orthopaedic surgery. We have had experience growing such a dedicated service within an academic department of orthopaedic surgery over the past 9 years.

Questions/purposes We explored (1) the use of a limb deformity service (LDS) in an academic department of orthopaedic surgery by examining data on referral patterns, our clinical volume, and academic productivity; and (2) the surgical breadth of cases comprising the patients of the LDS in an academic department of orthopaedic surgery by examining data on caseload by anatomic sites, category, and surgical techniques/tools.

Methods We (SRR, ATF, EWB) retrospectively examined data on numbers of surgical cases and outpatient visits from the limb lengthening and complex reconstruction service at the Hospital for Special Surgery from 2005 to 2013 to evaluate growth. We studied 672 consecutive surgical cases performed by our service for a sample period of 1 year, assessing referral patterns within and outside our medical center, anatomic region, surgical category, and surgical technique/tool. Academic productivity was measured by review of our service's publications.

Results During the time period studied (2005–2013), outpatient and surgical volume significantly increased by 120% (1530 to 3372) and 105% (346 to 708), respectively, on our LDS. Surgical volume growth was similar to the overall growth of the department of orthopaedic surgery. Referrals were primarily from orthopaedic surgeons (56%) and self/Internet research (25%). Physician referrals were predominantly from our own medical center (83%). Referrals from within our institution came from a variety of clinical services. Forty-nine peer-reviewed articles and 23 book chapters were published by staff members of our service. Anatomic surgical sites, surgical categories, and technique/tools used on our LDS were diverse, yet procedures were specialized to the discipline of limb deformity.

Conclusions There is a substantial role for an LDS within an academic department of orthopaedic surgery. With establishment of a dedicated service comes focus and resources that establish an environment for growth in volume, intramural and extramural referral, and purposeful research and education. The majority of referrals were from orthopaedic surgeons from our own medical center,

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
This work was performed at the Hospital for Special Surgery, New York, NY, USA.

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suggesting needfulness. The LDS provides patients access to specialized surgery. The number of intramural referrals suggests that the specialty service helps retain patients within our academic orthopaedic department. Future research will try to determine if such a dedicated service leads to improved outcomes, efficiency, and value.
Level of Evidence Level IV, retrospective study.

Introduction

The field of orthopaedic surgery has been in a continuous state of evolution, trending toward specialization [12]. Initially orthopaedic surgeons treated infections and deformities in pediatric and adult patients. As general surgery started to specialize, orthopaedic surgeons gradually began to take over the treatment of fractures [12]. Hand surgery was the first recognized orthopaedic subspecialty, forging a trend for further orthopaedic subspecialization [12]. With technologic advances in the second half of the 20th century, subspecialization continued, resulting in 22 subspecialty societies recognized today by the American Academy of Orthopedic Surgeons (AAOS) [13].

Limb lengthening and reconstruction surgery for the treatment of patients with limb deformities is a relatively new subspecialty of orthopaedic surgery in the United States, focusing on limb lengthening, deformity correction, and treatment of bone defects, infection, and nonunions in both adults and children. The subspecialty is often referred to as limb lengthening or limb deformity surgery. The Limb Lengthening and Reconstruction Society (LLRS), founded in 1989, became a recognized branch of the Board of Specialty Societies of the AAOS in 1999. There are currently only three dedicated limb lengthening and deformity fellowship programs in the United States that focus entirely on limb deformity treatment in both adults and children. The benefits of orthopaedic subspecialization and increased volume in other disciplines have been well documented [2, 5, 6]; however, the possible use of a distinct hospital-based limb deformity service has not yet been shown. As a relatively new subspecialty, the field of limb deformity is growing in the breadth of surgical options for deformity correction [9, 10]. For instance, recent, growing popularity of the motorized intramedullary nail requires a unique understanding of its uses and potential complications [8]. Despite increased awareness and practice of limb deformity surgery, it is rarely vested as a separate clinical service in an academic department of orthopaedic surgery. We believe that a dedicated clinical and academic service has the potential to enhance the quality of patient care, increase volume, and improve academic productivity and innovation. At our institution, we have had such an academic clinical service since our inception in 2005 consisting of two attending surgeons and dedicated support staff including two clinical/research fellows, two physician assistants, two outpatient nurses, and a service administrative coordinator. In the operating room, we have a dedicated team of circulating nurses and surgical technicians. Protocols for inpatient/outpatient order sets, physical therapy, and radiology have been established. Our research program consists of a research coordinator, a patient registry, and a photograph database. Patients are routinely enrolled in these and in ongoing studies. Our educational program includes a weekly preoperative planning conference and a weekly service conference that is used for core topics, journal club, psychomotor skills, and interdisciplinary conferences with other services in our department. Orthopaedic residents and medical students routinely do clinical rotations on our limb deformity service (LDS). We named our service the Limb Lengthening and Complex Reconstruction Service (LLCRS).

In our study, we sought to answer (1) what is the use of a LDS is in an academic department of orthopaedic surgery; and (2) what is the surgical breadth of cases of a LDS in an academic department of orthopaedic surgery? We examined data on clinical volume growth, referral patterns, our surgical cases, and academic productivity to answer question 1 and data on caseload by anatomic sites, categories, and surgical techniques and tools to address question 2.

Patients and Methods

We conducted an institutional review board-approved retrospective study at the LDS of a university-based, academic, orthopaedic-specialty hospital. The department of orthopedic surgery at our hospital is comprised of 95 surgeons and consists of 10 subspecialty services including adult reconstruction and joint replacement, foot and ankle, hand and upper extremity, hip preservation, limb lengthening and complex reconstruction, metabolic bone disease and tumor, orthopaedic trauma, pediatric orthopaedic, spine, sports medicine and shoulder. Our hospital also has a department of medicine, anesthesiology, and physiatry (physical medicine). The Physician Referral Service is a triage office that directs inquiring patients to various physicians based on the patient's clinical problem and insurance issues. The LLCRS is comprised of two attending surgeons. The senior surgeon was a member of the orthopaedic trauma service from 2000 to 2005. The recruitment of the second surgeon and the establishment of the LLCRS within the department of orthopaedic surgery occurred in 2005.

We (SRR, ESR, ATF, SZ, EWB) examined data on the number of our surgical cases and outpatient visits from 2005 to 2013 to evaluate the growth of our service. We also

collected volume data of the entire orthopaedic department from 2007 to 2013 to evaluate our service growth in relation to the departmental growth. Furthermore, we studied demographic data on 672 consecutive surgical cases performed on the LLCRS for a sample period of 1 year (March 2013 to February 2014). Our surgeons are dedicated to this service and are not part of other clinical services in the orthopaedic department.

On an ongoing weekly basis, surgeons (SRR, ATF) completed a multiple-choice data sheet for each of their surgical cases to indicate source of referral and if an intramural referral, the specific referring orthopaedic service. Other items on the data sheet included surgery site, surgical category, and technique/tool used. More than one category could be chosen for an individual patient accounting for varying total numbers in the various analyses for the sample year. Surgeon recall and the use of the medical record were used to complete the data sheet. At the end of the sample year, the data was organized and analyzed (EWB, ESR, SRR).

Study outcomes included outpatient visit volume, surgical volume, and referral sources, both within and outside our medical center; caseload by anatomic site; caseload by surgical category; and caseload by particular surgical technique/tool. Complications were recorded and classified as: (1) complications effectively rectified with unplanned surgery; and (2) complications not effectively rectified. Outcomes were also recorded and classified as: (1) patient satisfied and goals of treatment achieved; and (2) patient not satisfied and goals of treatment not achieved. Academic productivity of the service was assessed by review of our publications from 2005 through 2014, quantifying peer-reviewed articles, book chapters, review articles, and web-based publications.

Statistical Analysis

Evaluation of the annual rate of growth in the outpatient office visit and surgical cases was compared by calculation of an incidence rate ratio between the years 2005 and 2013. Similar rate ratios were calculated to evaluate the rate of growth between the service and the total hospital outpatient office visits and surgical cases from 2007 to 2013. Statistically significant percent change was defined as a p value of ≤ 0.05.

Results

From 2005 to 2013, annual LLCRS outpatient office visits significantly ($p < 0.001$) increased from 1530 to 3372 (120%). From 2005 to 2013, annual LLCRS surgical volume significantly ($p < 0.001$) increased from 346 to 708 (105%) (Fig. 1; Tables 1, 2). Significant ($p < 0.05$) annual LLCRS outpatient office visit and surgical growth was noted in the first 4 and 3 years, respectively (Table 2). Overall annual volume growth continued but at a more modest pace. Department of orthopaedic surgery growth is displayed to provide a perspective for the LLCRS growth (Fig. 1; Table 1). A comparison of annual growth in surgical volume showed similar progress in both the LLCRS and the department of orthopaedic surgery. Outpatient office visit departmental growth was greater than LLCRS growth, particularly in the years 2011 to 2013 (Fig. 2; Table 3).

During the sample year studied, 672 referrals to the LDS came from orthopaedic surgeons (377 of 672 [56%]), self/Internet research (169 of 672 [25%]), other physicians (48 of 672 [7%]), other healthcare professionals (35 of 672 [5%]), and other patients (41 of 672 [6%]) (Fig. 3). There were 460 physician referrals that were from our own medical center (382 of 460 [83%]) and from other medical centers (78 of 460 [17%]). Referrals from within our institution numbered 331 and came from a variety of clinical services, including foot and ankle (179 of 331 [54%]); orthopaedic trauma (34 of 331 [10%]); arthroplasty (40 of 331 [12%]); sports medicine (27 of 331 [8%]); tumor (13 of 331 [4%]); the hospital referral service (17 of 331 [5%]); and anesthesia, medicine, spine, hand, physiatry, and pediatrics combined (21 of 331 [8%]) (Fig. 4).

Surgical cases categorized by anatomic location were tibia (234 of 769 [30%]); ankle (243 of 769 [31%]); femur (122 of 769 [16%]); foot (66 of 769 [9%]); knee (71 of 769 [9%]); hip (21 of 769 [3%]); and upper extremity (12 of 769 [2%]) (Fig. 5). Surgical cases were divided into eight categories. The total number of 756 exceeds the 672 surgeries since cases could be placed into more than one category. The distribution and case examples are displayed (Table 4). Surgical cases were diverse but were specialized to the discipline of limb deformity.

Surgical cases categorized by the technique or tool used were circular frame (403 of 698 [58%]); monolateral frame (55 of 698 [8%]); static intramedullary nail (53 of 698 [8%]); integrated fixation—combination of internal and external fixation (56 of 698 [8%]); internal lengthening nail (43 of 698 [6%]); plate (39 of 698 [6%]); arthroplasty (38 of 698 [5%]); and arthroscopy (11 of 698 [2%]) (Fig. 6). A diversity of surgical techniques and tools was used in the discipline of limb deformity.

The sample year studied (March 2013 to February 2014) included 672 consecutive surgical cases performed on 448 patients on the LLCRS. All surgical cases were included. Multiple surgeries were performed with 135 patients having two surgeries, 28 patients having three surgeries, and

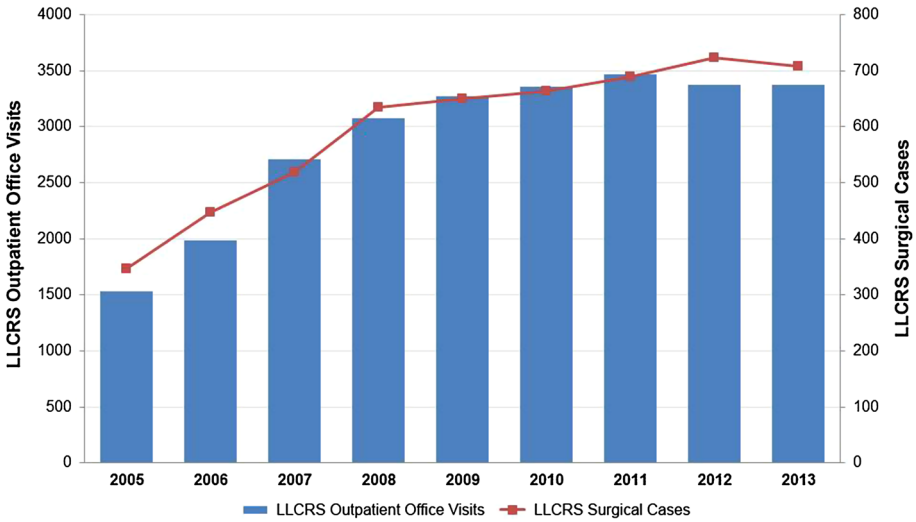

Fig. 1 Volume of service outpatient office visits and surgical cases from 2005–2013 is shown.

Table 1. Volume of service and hospital outpatient office visits and surgical cases per year, 2005–2013

Year	LLCRS outpatient office visits	Hospital outpatient office visits	LLCRS surgical cases	HSS surgical cases
2005	1530		346	
2006	1986		447	
2007	2712	20,7254	518	20,232
2008	3079	22,4203	635	22,700
2009	3268	24,4395	650	24,251
2010	3354	25,4269	664	25,247
2011	3471	26,5314	689	25,916
2012	3371	28,1664	723	27,672
2013	3372	29,6288	708	29,606

LLCRS = Limb Lengthening and Complex Reconstruction Service; HSS = Hospital for Special Surgery.

Table 2. Annual percent change of service of outpatient office visits and surgical cases, 2005–2013

Year 1	Year 2	LLCRS outpatient office visits				LLCRS surgical cases			
		N1	N2	Percent change	p value	N1	N2	Percent change	p value
2005	2006	1530	1986	29.8	< 0.001	346	447	29.2	< 0.001
2006	2007	1986	2712	36.6	< 0.001	447	518	15.9	0.022
2007	2008	2712	3079	13.5	< 0.001	518	635	22.6	< 0.001
2008	2009	3079	3268	6.1	0.018	635	650	2.4	0.676
2009	2010	3268	3354	2.6	0.291	650	664	2.2	0.699
2010	2011	3354	3471	3.5	0.157	664	689	3.8	0.497
2011	2012	3471	3371	−2.9	0.227	689	723	4.9	0.366
2012	2013	3371	3372	0.3	0.990	723	708	−2.1	0.692
Overall (2005–2013)		1530	3372	120.4	< 0.001	346	708	104.6	< 0.001

LLCRS = Limb Lengthening and Complex Reconstruction Service.

11 patients having four surgeries. Outcomes of 448 patients treated during the sample year were that goals were achieved and the patients were satisfied in 441 of 448 (98.4%) and goals were not achieved and patients were not satisfied in seven of 448 (1.6%). Complications effectively rectified with unplanned surgery occurred in 26 of 448 patients (5.8%) and complications not effectively rectified occurred in eight of 448 patients (1.8%) (Table 5).

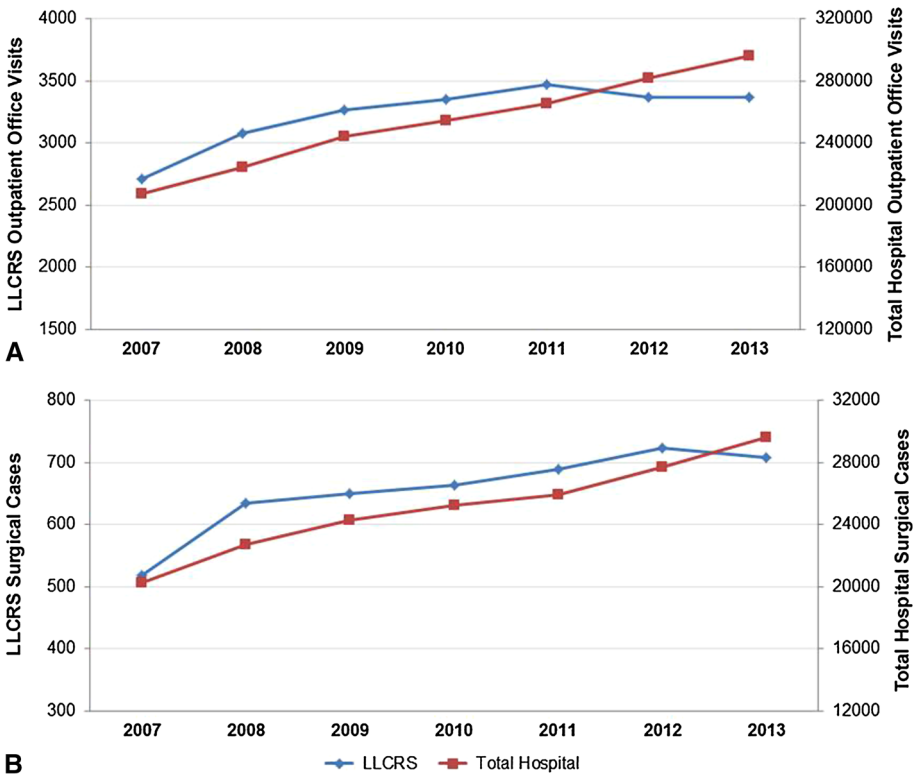

Fig. 2A–B From 2007 to 2013, (**A**) the rate of service and total hospital outpatient office visits and (**B**) the rate of service and total hospital surgical cases are shown.

Table 3. Comparison of annual percentage change of service versus total hospital outpatient office visits and surgical cases, 2005–2013

Year 1	Year 2	Percent change in outpatient office visits			Percent change in surgical cases		
		LLCRS	Hospital	p value	LLCRS	Hospital	p value
2007	2008	13.5	8.2	0.068	22.6	12.2	0.140
2008	2009	6.1	9.0	0.293	2.4	6.8	0.450
2009	2010	2.6	4.0	0.582	2.2	6.8	0.735
2010	2011	3.5	4.3	0.736	3.8	2.6	0.845
2011	2012	−2.9	6.2	< 0.001	4.9	6.8	0.904
2012	2013	0.3	5.2	0.040	−2.1	7.0	0.098
Overall (2007–2013)		24.3	43.0	< 0.001	36.7	46.3	0.244

LLCRS = Limb Lengthening and Complex Reconstruction Service.

From January 2005 to July 2013, staff members of our dedicated service published 49 peer-reviewed articles, 23 book chapters, review articles, and web-based publications focused on limb deformity topics.

Discussion

Background and Rationale

Limb lengthening and reconstruction surgery is a relatively new subspecialty of orthopaedic surgery in the United States. Despite increased awareness and practice of the subspecialty, it is rarely vested as a separate clinical service in an academic department of orthopaedic surgery. Our findings support the use of such a dedicated service. Significant clinical growth has occurred and an environment has been created that has supported focused clinical and academic work. Surgical outcomes have been excellent and academic productivity has been substantial. Referral patterns, both intramural and extramural, suggest needfulness and an improved access for patients to this specialized care. Analysis of the procedures done suggests great diversity in

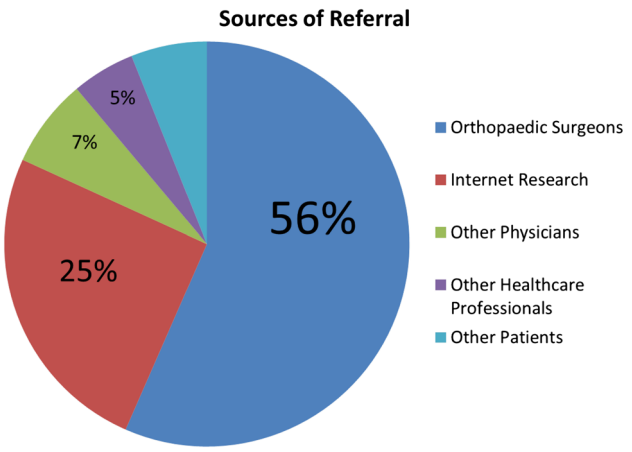

Fig. 3 Sources of referral to the LLCRS at the Hospital for Special Surgery are shown.

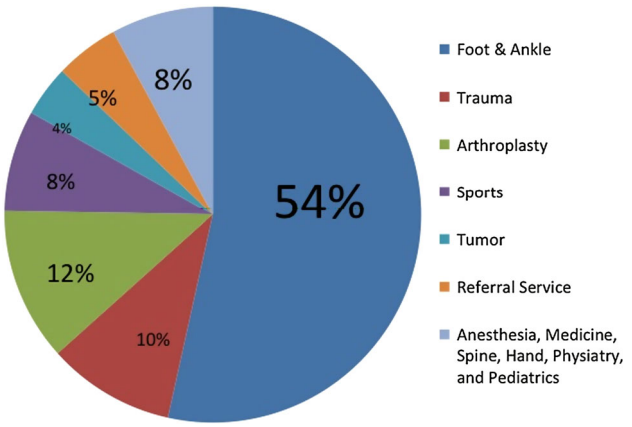

Fig. 4 Referrals from different clinical services of our department of orthopaedic surgery are shown.

anatomic location and use of surgical technique yet all focused on the discipline of limb deformity.

The vast field of orthopaedic surgery has been gradually undergoing specialization, reflecting technologic advances, improved surgical methods, and increased knowledge of orthopaedic pathology [11–13]. There are now 22 AAOS-recognized orthopaedic specialty societies, including the LLRS. The field of limb deformity is undergoing rapid growth and is attracting increasing numbers of orthopaedic surgeons [8–10, 14]. By quantifying and qualifying the growth and volume of the surgical and academic activity on our service, we have demonstrated the role and use of such a service within a larger parent orthopaedic department.

Limitations

Our study examined outpatient and surgical volumes, referral patterns, surgical caseload, outcomes, complications,

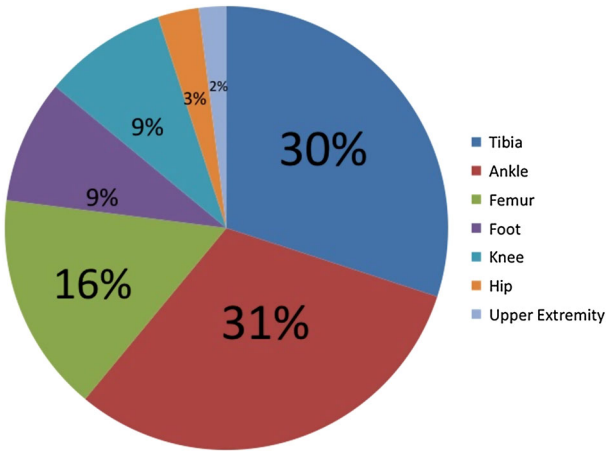

Fig. 5 Surgical caseload by anatomic location is shown.

and academic publications; however, the study was limited by lack of comparison of similar procedures performed between a dedicated service in a nonspecialized service. This would require comparison with a different institution and was beyond the scope of this study. This will be examined in a future study. Also, data were obtained directly from the surgeons based on weekly recall and use of the medical chart. There was some subjectivity as to how cases were categorized and cases were sometimes assigned more than one category accounting for varying total numbers in each analysis. There is inevitable bias in this retrospective study. Data have been obtained by recall and categorization has been subjective. Furthermore, we are invested in the success of the LLCRS, which also can elicit bias. We have tried to be objective and accurate.

We found that between 2005 and 2013, annual outpatient office visits and annual surgical volume significantly grew. Surgical volume growth was similar to the growth of the department of orthopaedic surgery. Growth of outpatient office volume was greater in the department of orthopaedic surgery than on the LLCRS. This is likely related to a higher proportion of surgical cases to office visits on the LLCRS than the department in general. We were unable to find published case volume data regarding limb lengthening and reconstruction surgery at other hospitals. Studies have shown associations among surgeon and hospital case volume and positive outcomes in patients undergoing shoulder, hip, and knee arthroplasty [2, 5, 6]. As a result, surgical and hospital volume can be used as a partial surrogate for surgical outcomes. Based on our growing case volume and having a group of surgeons dedicated to limb lengthening and reconstruction may lead to better surgical outcomes. At this point, this is speculation. However, a future study comparing the outcomes and complications of our dedicated service with other institutions that perform similar surgery without a dedicated

Table 4. Analysis of sample year surgical cases by category

Surgical category	Number of cases	Percent of total cases (756)	Examples of surgical procedures
Foot and ankle	295	39	(1) Ankle distraction; (2) supramalleolar osteotomy using circular frame; (3) complex ankle fusion using circular frame or intramedullary nail
Adult deformity	188	25	(1) Proximal tibial osteotomy to correct deformity using circular frame; (2) distal femoral osteotomy using plate; (3) femur lengthening using internal lengthening nail; (4) treatment of chronic osteomyelitis with sequestrectomy and insertion of antibiotic coated intramedullary nail
Trauma and reconstruction	140	19	(1) Treatment of segmental tibial fracture and tibial plateau fracture with circular external fixation; (2) repair of tibial malunion with osteotomy and correction using a circular external fixator; (3) repair of tibial nonunion/ bone defect with circular external fixation and bone transport; (4) repair of femur malunion with osteotomy and insertion of intramedullary nail
Arthroplasty	49	6	(1) TKA to correct deformity and advanced arthrosis; (2) knee fusion for complex failure of TKA
Pediatric	39	5	(1) Tibia and fibula lengthening for congenital leg length discrepancy; (2) femur lengthening for growth arrest using internal lengthening nail; (3) guided growth for femur and/or tibia deformity using plate
Limb salvage	17	2	(1) Reconstruction of infected nonunion of ankle fusion using circular external fixation; (2) tibiocalcaneal fusion for Charcot destruction of talus using circular external fixation; (3) treatment of infected nonunion and bone loss after failed pilon fracture using circular external fixation and bone transport
Tumor	14	2	(1) Reconstruction of distal tibial bone defect (after resection of low-grade osteosarcoma) with bone transport; (2) reconstruction of femoral defect (after failure of previous allograft and free fibula) using bone transport over a nail
Upper extremity	14	2	(1) Humerus lengthening for growth arrest using monolateral frame; (2) radius and ulna osteotomy using circular frame

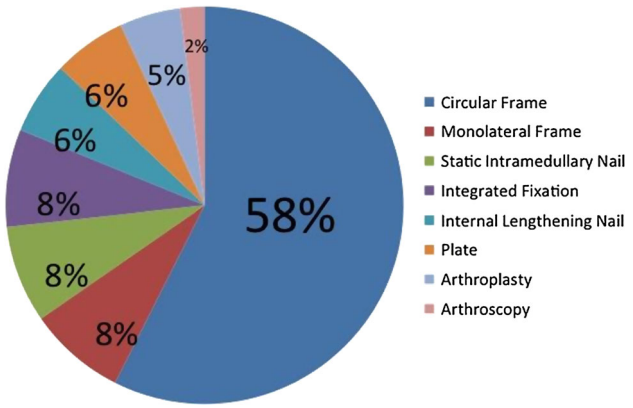

Fig. 6 Surgical tools and techniques used by the LLCRS are displayed.

center is planned. Other studies have shown that specialized orthopaedic departments and services such as pediatrics and trauma, help improve efficiencies, decrease use costs, and shorten lengths of stay in hospitals [1, 15]. Higher volume also gives hospitals bargaining power over industry, which may lower costs. Future comparative studies on patient outcomes, efficiency, and value between dedicated LDS and nonspecialized centers represent an important area of research. Additionally, increasing case volume indicates that there exists a previously unrecognized need that can be fulfilled by surgeons who work specifically in limb deformity. Our referrals were predominantly from orthopaedic surgeons and from prospective patients doing their own Internet research (Fig. 3). Moreover, orthopaedic surgeon referrals were predominantly intramural, which suggests that without the specialty service, the institution could have lost these patients. In addition, new patients have been drawn to the hospital because of the availability of the specialized care. Marketing of the service to increase patient and physician awareness and education is more readily done when there is a dedicated program. The fact that most referrals were from other orthopaedic surgeons may indicate that orthopaedic surgeons who do not specialize in limb deformity may be unable or unwilling to perform limb lengthening and reconstruction surgery as a result of its specialized nature, highlighting the need for such a specialty service. This correlates with the growing trend in subspecialization of orthopaedic surgery [12, 13]. Forty-nine peer-reviewed articles and 23 book chapters, review articles, and web-based publications have been published from our LLCRS staff members between 2005 and 2014. Such high academic productivity has been made possible by a dedicated LDS within the department of orthopaedics. Specialization has led directly to innovation and solutions to previously

Table 5. Complications in 448 patients treated during the sample year

Complications effectively rectified with unplanned surgery	Number of patients
Inability to distract treated with revision of implant or frame	4
Frame instability treated with frame modification	2
Infection in bone or joint treated with irrigation and débridement	2
Refracture after frame removal treated with internal fixation	4
Nonunion treated with internal fixation	6
Joint contracture treated with frame extension across joint	1
Neuropraxia during lengthening treated with nerve decompression	2
Nonunion treated with revision surgery and reapplication of frame	2
Regenerate nonunion treated with iliac crest bone grafting	2
Metatarsal-phalangeal joint stiffness after metatarsal lengthening treated with lysis of adhesions	1
Total	26 (5.8%)
Complications not effectively rectified	**Number of patients**
Recurrence of severe knee contracture treated with knee disarticulation	1
Refracture of complex ankle fusion	1
Infection of complex ankle fusion treated at another center (patient moved across the country)	1
Deformation of regenerate (elected not to further treat)	2
Nonunion and infection of complex ankle fusion treated with below-knee amputation	2
Ankle distraction complicated by severe arthrofibrosis and stiffness	1
Total	8 (1.8%)

unsolved limb deformity problems. The academic output parallels the development and evolution of hand surgery as an orthopaedic subspecialty. The quantity of research and grant money for research increased as hand surgery services, centers, and training programs increased in number and organization and accreditation [7].

Surgeons who subspecialize in limb lengthening and reconstruction are involved in patient cases that include the whole body (Fig. 5) with a variety of etiologies illustrated by the diverse service referrals (Fig. 4). Limb lengthening and reconstruction procedures require an in-depth knowledge of recent advances within the field [9, 10]. There is apparent overlap with other subspecialties, including adult reconstruction, orthopaedic trauma, foot and ankle, pediatric orthopaedics, tumor, and upper extremity. However, limb lengthening and reconstruction is a unique and distinct orthopaedic subspecialty, which uses the principles of deformity correction, recognizing the intimate relationships among the hip, knee, and ankle. Osteotomy is used to correct deformity and leg length discrepancy, adhering to the principles of the Ilizarov method [3, 4]. We use external fixation as well as internal fixation and perform limb salvage and joint preservation surgery. Limb lengthening and reconstruction surgery address both simple patient deformities and complex patient cases with multiapical deformity, bone loss, and infection. It is distinct from other orthopaedic surgery subspecialties, and colleagues facing a complex patient problem often consult a limb deformity specialist for an alternative orthopaedic approach. A dedicated LDS does not compete with the other services, but instead compliments their skill sets with unique perspective and techniques.

Conclusions

There is a substantial role for an academic clinical service dedicated to limb lengthening and reconstruction within an academic department of orthopaedic surgery. With establishment of a dedicated service comes focus and resources that establish an environment for growth in volume, intramural and extramural referral, and purposeful research and education. Future research will try to determine if such a dedicated service leads to improved outcomes, efficiency, and value. There has been significant growth in our surgical volume matching the growth of the orthopaedic department. Academic activity has been abundant. The majority of referrals to our LDS were from orthopaedic surgeons within our own medical center, suggesting needfulness. Numerous intramural referrals suggest that the specialty service helps retain patients within our academic orthopaedic department. Foot and ankle, orthopaedic trauma,

arthroplasty, and sports medicine were the main referring services. Patients who have the need for specialized limb reconstruction can now access our specialty service. The significant ($p < 0.001$) growth in surgical patient volume of our LDS may help the orthopaedic department improve patient outcomes and efficiency, as suggested by studies in a variety of other orthopaedic subspecialties; however, future studies are necessary to confirm this hypothesis. Furthermore, future studies to analyze the learning curve by comparing outcomes of experts with new users would be valuable. Orthopaedic residents and fellows may consider a career dedicated to the emerging subspecialty. Hospital leadership may understand the potential for surgical volume growth and improved clinical outcomes.

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