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A Retrospective Study of Operating Room Utilization and Efficiency in a
Pediatric Dental Residency Program

A thesis submitted in partial fulfillment of the requirements for the degree of Master of
Science in Dentistry at Virginia Commonwealth University

by

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ABSTRACT

A RETROSPECTIVE STUDY OF OPERATING ROOM UTILIZATION AND EFFICIENCY IN A PEDIATRIC DENTISTRY RESIDENCY PROGRAM

By Brian Burke, D.M.D.

A Thesis Submitted In Partial Fulfillment Of The Requirements For The Degree Of Master Of Science In Dentistry At Virginia Commonwealth University.

Virginia Commonwealth University, 2014

Major Director: Patrice B. Wunsch, D.D.S, M.S., Director,
Advanced Education Program In Pediatric Dentistry

Purpose: The purpose was to assess and understand operating room (OR) utilization and efficiency in a pediatric dental residency program.

Methods: A retrospective study was performed using chart extraction from 778 patients completed by both pediatric dentistry faculty (n=7) and residents (n=17) in an ambulatory care setting over a 32 month period (between July 2010 and March 2013). Patterns in OR usage time were determined by documenting various timing metrics (start and stop times for anesthesia, start and stop times for the dental procedure, times for throat pack in and out), noting patient information (age and ASA patient classification status), and creating variables by grouping data by clinical provider type and dental procedure. OR usage time was analyzed using multiple regression to estimate the per-tooth or per-mouth time for each type of procedure.

Results: The median procedure time was 75 minutes (range= 1 to 517 minutes). Multiple regression indicated that for the average patient, a faculty member took 63.8 minutes (95% CI = 60.8 to 66.7 minutes) and a resident took 81.9 minutes (95% CI = 78.7 to 85.0 minutes, $P < .0001$). These results demonstrate that the appropriate scheduling of operating room should be based on the proficiency level of provider as well as the complexity of the dental procedure.

Conclusion: This study concludes that pediatric dental operating room planning and scheduling in teaching hospitals should take into account real constraints such as residents' level of training and skill.

BACKGROUND AND SIGNIFICANCE

Early Childhood Caries: A Significant Public Health Problem

Early childhood caries (ECC), formerly termed nursing bottle caries and baby bottle caries, is a significant and leading public health problem.¹ According to the Centers for Disease Control and the American Dental Association, in the United States, dental caries remain the most common chronic disease of children aged 6 to 11 years and adolescents aged 12 to 19 years. Additionally, tooth decay is four times more common than asthma among adolescents aged 14 to 17.² Epidemiologic data from the National Center for Health Statistics document the increase in the ECC prevalence as follows: overall, dental caries in primary teeth increased from 40% (1994-1998) to 42% (1999-2004), among children aged 2 to 5 years, prevalence of primary tooth caries increased from 24% to 28%, and caries rates in children aged 2 to 11 years remained greatest for lower socio economic status groups.³ While the collective oral health of children has improved over the past several decades, recent trends show the prevalence of caries in primary teeth increasing in children aged 2 to 11 years. Furthermore, children experiencing caries as infants or toddlers have a much greater probability of subsequent caries in both the primary and permanent dentitions.⁴ This chronic, infectious disease warrants immediate and comprehensive oral care.

Pediatric Dentistry: Dental Rehabilitation and General Anesthesia

According to the American Academy of Pediatric Dentistry (AAPD), those children at risk for ECC should receive dental care by a practitioner who has the academic training, clinical experience, and content knowledge expertise to manage both the child's behavior and the disease process. Due to the aggressive nature of ECC, areas of demineralization and hypoplasia can rapidly develop cavitation and, if left untreated, the disease process can quickly spread to new carious lesions in both the primary and permanent dentitions, involve the dental pulpal tissue leading to dental infection, and result in potentially life threatening fascial space involvement.⁵ Additional negative consequences associated with ECC include hospitalizations, emergency room visits, increased treatment costs, risk for delayed physical growth and development, loss of time in school, and increased days with limited physical activity.⁶ As trained specialists, pediatric dentists are on the front lines of treating the chronic, persistent, increasing, and significant public health problem of decay.

Pediatric dentists strive to provide optimal restorative treatment while fostering positive attitudes in children about dental care. In fighting decay and providing comprehensive care, most pediatric dental treatment is offered in a traditional office setting using behavioral guidance techniques (voice control, positive reinforcement, rewards, etc.), local anesthesia, and, when indicated, a variety of adjunctive pharmacologic interventions with moderate sedation.⁷ However, for a small subset of patients with significant disease severity and an inability to cooperate, dental rehabilitation using general anesthesia is the recommended treatment modality. For instance, in the state of Virginia, utilization of general anesthesia for dental procedures

appears to be very low (less than 0.15 percent).⁸ This small group of children, including children with special health care needs (SHCN), require general anesthesia to receive comprehensive dental care in a safe, humane, and comprehensive fashion.^{8,9}

The use of general anesthesia is not appropriate for all dental procedures or pediatric patients. The AAPD endorses general anesthesia for pediatric dental patients who: are unable to cooperate; experience ineffective local anesthesia; are extremely fearful, anxious or uncommunicative; require significant surgical procedures; can benefit from general anesthesia protecting them from psychological trauma and/or reducing medical risks; and require comprehensive care.⁹⁻¹² Though most patients will never need general anesthesia for dental procedures, its use is occasionally determined to be medically necessary in order to render the patient unconscious, free of pain, and immobilized and to allow the dentist to provide safe and effective dental care. For the select group of pediatric dental patients who require general anesthesia, this treatment modality provides optimal conditions to perform dental rehabilitation, especially in young children and patients with special health care needs with significant decay characterized by multiple carious lesions and/or complex treatment needs.¹³

While general anesthesia is a costly method of delivering dental care, it offers unmatched benefits.¹⁴ Dental rehabilitation under general anesthesia is typically completed in a single visit. Therefore, if a child needs more than three moderate conscious sedation visits, general anesthesia is less costly than sedation.¹⁵ Moreover, general anesthesia avoids intangible costs to the family such as missed wages associated with taking time off from work for multiple appointments, missed school days, and the interruption to the normal family routine.¹⁶ This fragmenting of the daily routine has a

particularly negative affect on families of patients with special needs who typically require structured daily routines.

Parental Attitudes toward General Anesthesia

Early studies in the 1980s and 1990s ranked general anesthesia and papoose boards as the least acceptable techniques for behavioral management based on results of parental surveys.^{17,18} However, parental acceptance of general anesthesia, relative to other behavior management techniques, has increased over the past two decades and today carries a high degree of acceptance among parents.^{19,20} This trend may be due to increased familiarity with outpatient general anesthesia.¹⁷ Contemporary parents, as opposed to parents in past decades, may be more likely to have had personal or family experience with outpatient general anesthesia. In studies examining a hierarchy of behavioral techniques, general anesthesia has been consistently acceptable to parents, but also viewed as a modality of last resort.⁸

Parents today seem more focused on the quality of life benefits associated with dental treatment as opposed to the risks associated with general anesthesia.¹⁷ According to one study, seventy two percent of parents believed that the overall health of their child had improved as a result of comprehensive dental rehabilitation using general anesthesia.¹⁸ An additional study showed that following treatment under GA, parents reported a lessening in the amount of dental pain and improvement in their child's ability to sleep and eat, and an acceptance of parental tooth brushing.¹⁶ Research also indicates that postoperative pain is mild and subsides significantly over the first week after surgery.²¹ Parents in contemporary society view their child's improved daily functioning and

renewed ability to eat and sleep without pain as main determinants of satisfaction following dental treatment under general anesthesia.²²

Operating Room Utilization

Following a medical evaluation that deems a patient healthy enough to undergo dental treatment under general anesthesia, a pediatric dental patient stay in the hospital is divided into pre-operative, operative, and post-operative phases. The four main components of the operative phase are as follows:

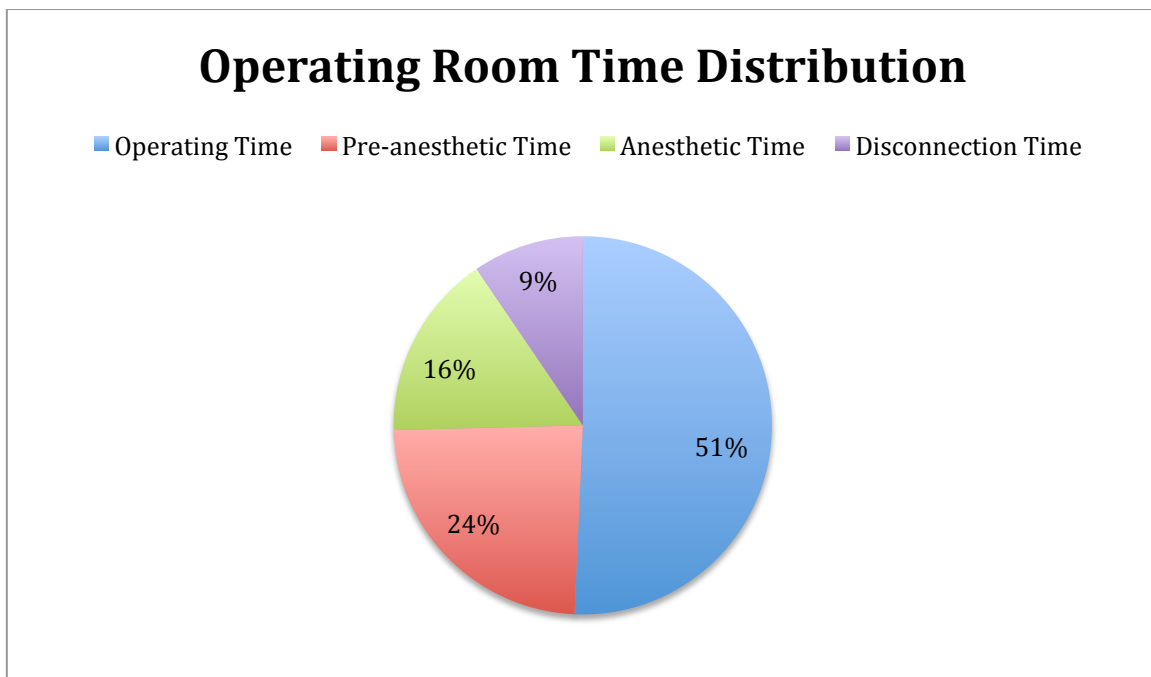
- Pre-anesthetic time— the time between the official start of the operation or the time that the previous patient was sent to recovery, stage also includes determining patient's American Society of Anesthesiology (ASA) level;
- Anesthetic time— the time from the start of the either intubation or gaseous induction, including the connection to the anesthetic machine and the monitoring devices;
- Operating time— the time taken to perform the dental procedure by the dentist;
- Disconnection time— the time between the end of the operation and the patient leaving the operating room and entering the recovery room.²³

These are the major components of efficiency in operating room utilization.

Treating pediatric dental patients in a hospital setting requires careful planning that takes into consideration scheduling dental patients against the hospital-wide surgical demand of patients with other medical needs. A recent study examining 71 operating room schedules for dental procedures requiring general anesthesia and being conducted at a hospital based, pediatric dental training program over a three-year period showed 21%

of cases resulted in poor operating room utilization.²³ Additionally, as shown below in Figure 1, 75% of operating room time distribution was determined to be pre-anesthetic time and procedure time. The latter accounts for the single greatest portion of operating room time (51%) and when the dentist is directly treating the patient. Missing from existing literature on operating room utilization for dental treatment is data on the amount of time taken for radiographic survey.

Figure 1. Operating Room Time Distribution²³



In determining how much time to schedule for an operating room case, the best determinants are the pre-anesthetic time and dental procedure time. However, it can be difficult to accurately predict the duration and variability of pediatric dental procedure time and therefore can result in overutilization and underutilization of the allotted operating room time. Overutilization is defined as the time used by scheduled procedures

beyond the scheduled time. The overruns associated with overutilization incur overtime costs and creates problems with staff retention.²⁴ Underutilization is another form of poor utilization of operating room time, and is defined as the time during scheduled operating hours that is not used for patient care.²⁵ A recent time and cost analysis of pediatric dental treatment with general anesthesia estimated the average cost per minute in the operating room to be \$19.27.²⁶ Beyond direct costs, improving operating room utilization for pediatric dental procedures is advantageous for several reasons including: improved hospital resource allocation, increased number of patients able to receive dental rehabilitation, and a reduction in waiting time to receive dental treatment in the operating room.¹⁰

Pediatric Dental Resident Training

As leaders in the dental profession, post-graduate pediatric dental residency programs strive to continually strengthen the safety and effectiveness of general anesthesia techniques for the dental patient. Therefore, hospital dentistry is an integral part of the curriculum of all accredited advanced pediatric dental training programs.²⁷ Families of children with complex dental needs and/or medical conditions often must rely on a relatively small number of “safety net” dental providers located primarily in hospital-based and dental school training programs.^{15, 28} Measurements of operating room demand among pediatric dental programs note a steady increase in patients seeking treatment. For example, a recent study of training programs in the United States showed that 81% of pediatric program directors requested additional operating room time, but only 46% were granted their requests.²⁸ Factors that limit operating room access for

dental treatment include scheduling dental patients versus patients with other medical needs, poor utilization of operating room time, and ineffective operating room scheduling.²⁹

Resident training affects surgical, patient, and hospital end points including outcomes, complications, mortality, length of hospitalization, cost, and surgery length. It has been shown in graduate medical education literature that, when compared with attending surgeon procedure duration, residents take longer to perform procedures.³⁰⁻³³ The largest study to date analyzed approximately 115,000 surgical cases and compared the length of procedure time for three commonly performed procedures. The authors then compared procedure time between cases performed by an attending surgeon alone and those assisted by senior or junior residents. Both resident cohorts showed significantly longer operative times compared with the attending physician cohort.³⁴ In fact, increased operative times for the purposes of resident training have been estimated to cost \$53 million annually.³⁵

However, advancement through successive levels of residency requires gaining increasing skill, technical performance, and independence in decision making. For instance, research also shows that as residents progress through training, they perform the same procedure faster.³⁶ Additional research illustrates that a learning curve is demonstrated whereby senior residents improve their proficiency, allowing similar operative times compared to attending faculty.³⁵

Pediatric dental training programs generally consist of faculty dental operators as well as two resident classes defined by the year of admittance. As training progresses, residents become more knowledgeable, proficient and efficient with dental procedures

and operating room protocols. Recognition of differing proficiency levels of residents within a training program may not be reflected in scheduling operating room times, or even the complexity of the dental rehabilitation, leading to costly overutilization and underutilization of the operating room time slot. Therefore, dentist operator type is a key factor that impacts accurately scheduling time needed in the operating room.

This study hypothesizes that first year pediatric dental residents will take longer time to complete procedures than second year residents and faculty members. Therefore, the level of resident will likely have an impact on operative times. To better understand and improve planning for operating room scheduling in pediatric dental residency programs, this retrospective study examines the operating times of faculty and two levels of pediatric dental residents in an ambulatory care setting.

METHODS

This 32 month study included a chart review of all pediatric dental patients in the VCU electronic medical record system (Axium) undergoing treatment under general anesthesia at one of VCU's four ambulatory care settings. Both faculty and resident cases were included in this study. Excluded from the study were joint cases with other departments in the VCU health systems (OMFS and ENT) and charts with incomplete documentation. A total of 778 cases met the study requirements.

Operating room times and dental procedure codes were collected using the electronic medical record. Operating room times were captured in four time points: Anesthesia start; Procedure start; Procedure end; and Anesthesia discharge. ASA classifications were also included in this study. Dental procedure codes (CDT codes) were collapsed into CDT code groups and then further subdivided into primary and permanent teeth. There are seven groups of procedures counted according to how many were performed on primary teeth A-T D2930, D2140, D2150, D2391-3, D9970, and D9971. Additional codes included restorations for primary anterior teeth D2932, D2934, Extractions D7140, and D7210. These codes were also divided into anterior and posterior categories. Procedures performed on permanent teeth were divided into seven groups: Anterior teeth D2931, D 2150, D2330-2, D2335 ; Posterior teeth D2140, D2150, D2391-3; Extractions D7140, D7210; Sealants D3151; Endodontic treatment of anterior and posterior teeth. There were four categories of full mouth procedures including

Debridement D4210, D4271, D4342; Fluoride application D1203, D1204-8; Prophylaxis D1110, D1120 and miscellaneous procedures listed under the category “other.”

Statistical Analysis: A multiple regression procedure was used to analyze procedure time as a function of the 19 procedure groups and ASA classification. Procedure times were estimated separately for residents and faculty.

RESULTS

The specific aim of this study was to determine if there was a correlation between dental operator experience level and procedure time. We hypothesized that pediatric dental residents would take longer time to complete procedures than faculty members. To examine this hypothesis, dental procedure codes were collapsed into 19 groups. Then, by looking at the average number of procedures, we created an average patient from which we could compare the efficiency of faculty and residents during an average patient operating case. As shown in Table 1, the average patient had 3.8 primary teeth Prefab Ss crown and that individual patients had between 1-14 stainless steel crowns placed.

Table 1: Average Number of Procedures Per Patient

Procedure	Number of procedures or patients				Procedures per patient		
	Faculty		Residents		Mean	Median	Range
	Procedures	Patients	Procedures	Patients			
<i>Preparation</i>							
Radiograph	236	244	323	309	0.976	1	0 7
<i>Primary teeth</i>							
Prefab Ss crown	1623	315	1314	269	3.781	4	0 14
Prefab resin crown	255	84	202	73	0.610	0	0 12
Restoration, anterior tooth	151	86	126	72	0.357	0	0 6
Restoration, posterior tooth	339	117	218	99	0.718	0	0 9
Extraction, anterior tooth	591	176	562	168	1.485	0	0 12
Extraction, posterior tooth	357	140	398	150	0.968	0	0 8
Sealant	58	17	228	78	0.369	0	0 8
<i>Permanent teeth</i>							
Prefab Ss crown	23	10	48	16	0.091	0	0 14
Restoration, anterior tooth	19	11	65	22	0.108	0	0 8
Restoration, posterior tooth	122	41	172	58	0.376	0	0 14
Extraction	55	17	56	23	0.138	0	0 11
Sealant	206	65	270	68	0.613	0	0 16
Endodontics, anterior tooth	138	70	69	42	0.265	0	0 4
Endodontics, posterior tooth	574	206	292	151	1.115	0	0 8
<i>Whole mouth</i>							
Debridement	15	15	18	18	0.043	0	0 1
Fluoride	345	345	300	300	0.830	1	0 1
Prophy	338	338	303	303	0.826	1	0 1
Space maintenance	29	18	23	17	0.067	0	0 4
Other	40	21	10	7	0.064	0	0 6

Further, a multiple regression procedure was used to analyze procedure time as a function of the 19 procedure groups. The intent was to estimate the relationship between these counts, separately for the faculty and residents. The multiple regression model was statistically significant ($P < .0001$). As shown in Table 2, the model indicated that for the average patient, a faculty member took 63.8 minutes (95% CI = 60.8 to 66.7 minutes) and a resident took 81.9 minutes (95% CI = 78.7 to 85.0 minutes, $P < .0001$).

The model also estimated the amount of time each procedure took to complete. The estimates show, for example, that faculty doing a prefabricated crown on primary teeth take an average of 5.3 minutes per tooth (95% CI=4.1 to 6.4) and that residents take an average of 6.8 minutes per tooth (95% CI=5.5 to 8.1).

Further, as displayed in Table 2, the regression model tested whether the faculty minutes were different from the resident minutes and there was no evidence for a statistically significant difference ($P=0.0805$). Another important interpretation of the estimates occurs when the lower limit of the 95% CI is below zero. For instance, the estimate for faculty extraction of an anterior tooth is that it takes 0.4 minutes, but note that the 95% CI includes zero (zero is between -1.1 and +2.0). The interpretation of 95% CI is that it's plausible that the faculty time estimate is zero. Similarly, the resident estimate for extraction of an anterior tooth is also plausibly zero, and that the faculty and resident value are not different ($P > 0.9$). After adjusting for the effect of each of 19 procedure groups, ASA had no effect on procedure time.

Table 2: Average Minutes Per Procedure

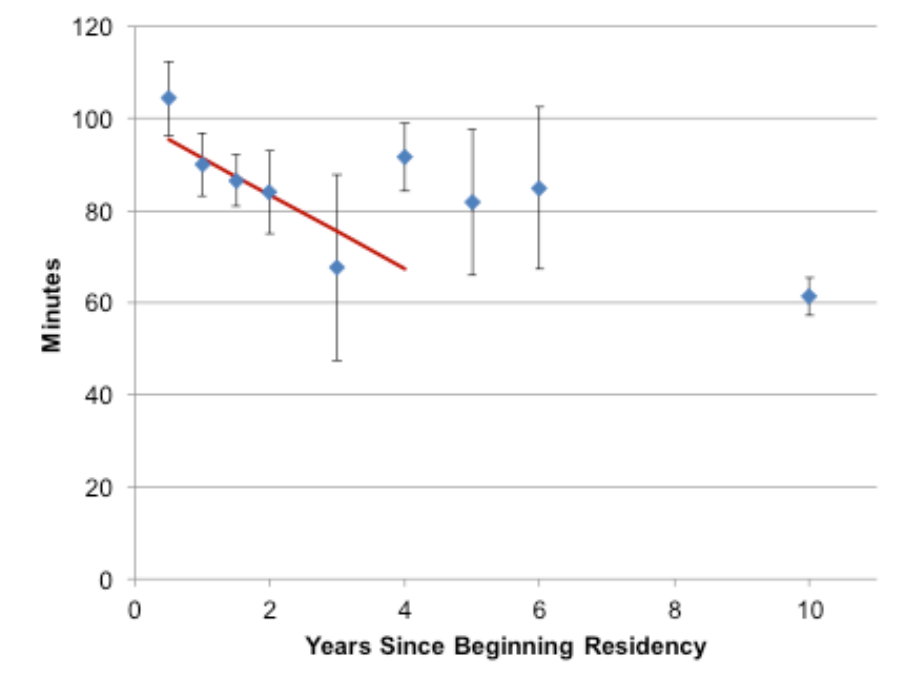
Procedure	Faculty			Residents			p-value	
	Minutes	95% CI		Minutes	95% CI		Both zero	Equal
Preparation Time								
Setup	47.0	40.7	53.4	40.3	34.4	46.1	<.0001	0.1224
Radiograph	-2.1	-7.1	2.8	-0.7	-5.3	4.0	0.4096	0.6693
Average preparation time	44.9	41.5	48.4	39.6	36.7	42.6		0.0211
Procedure Time								
Setup	22.4	13.1	31.7	15.3	6.3	24.3		0.2783
<i>Primary teeth</i>								
Prefab Ss crown	5.3	4.1	6.4	6.8	5.5	8.1	<.0001	0.0805
Prefab resin crown	10.4	7.8	12.9	11.5	8.8	14.2	<.0001	0.5589
Restoration, anterior tooth	6.5	3.1	10.0	5.6	1.8	9.3	<.0001	0.7134
Restoration, posterior tooth	2.4	0.4	4.4	4.4	1.9	7.0	0.0002	0.2113
Extraction, anterior tooth	0.4	-1.1	2.0	0.5	-1.1	2.1	0.7272	0.9789
Extraction, posterior tooth	4.5	2.5	6.5	1.9	0.0	3.8	<.0001	0.0629
Sealant				-0.4	-2.4	1.6	0.6896	
<i>Permanent teeth</i>								
Prefab Ss crown	9.6	1.7	17.5	32.2	28.9	35.6	<.0001	<.0001
Restoration, anterior tooth	32.7	22.0	43.3	11.6	7.5	15.6	<.0001	0.0003
Restoration, posterior tooth	6.8	4.0	9.7	4.5	1.9	7.2	<.0001	0.2512
Extraction	1.0	-2.7	4.7	7.2	2.4	11.9	0.0117	0.0455
Sealant	1.7	-0.5	4.0	3.1	1.6	4.7	0.0002	0.3071
Endodontics, anterior tooth	-4.6	-8.4	-0.8	0.2	-5.3	5.8	0.0575	0.1578
Endodontics, posterior tooth	-0.4	-2.1	1.4	4.2	1.6	6.8	0.0056	0.0040
<i>Whole mouth</i>								
Debridement	-3.0	-18.8	12.8	5.1	-9.8	19.9	0.7464	0.4660
Fluoride	12.8	-0.9	26.4	-13.5	-26.1	-0.9	0.0206	0.0056
Prophy	-13.1	-26.2	0.0	26.4	13.3	39.6	<.0001	<.0001
Space maintenance	3.3	-4.3	10.9	21.0	11.0	31.0	0.0002	0.0060
Other	0.3	-5.1	5.7	9.3	-3.9	22.5	0.3792	0.2138
Average procedure time	63.8	60.8	66.7	81.9	78.7	85.0		<.0001
Total Time								
Average total time	134.2	127.3	141.0	145.4	139.8	151.0		0.0135

Notes: Prep time n=520, procedure time n=776, Total time n=446

We also modeled the average time after collapsing experience into 9 groups.

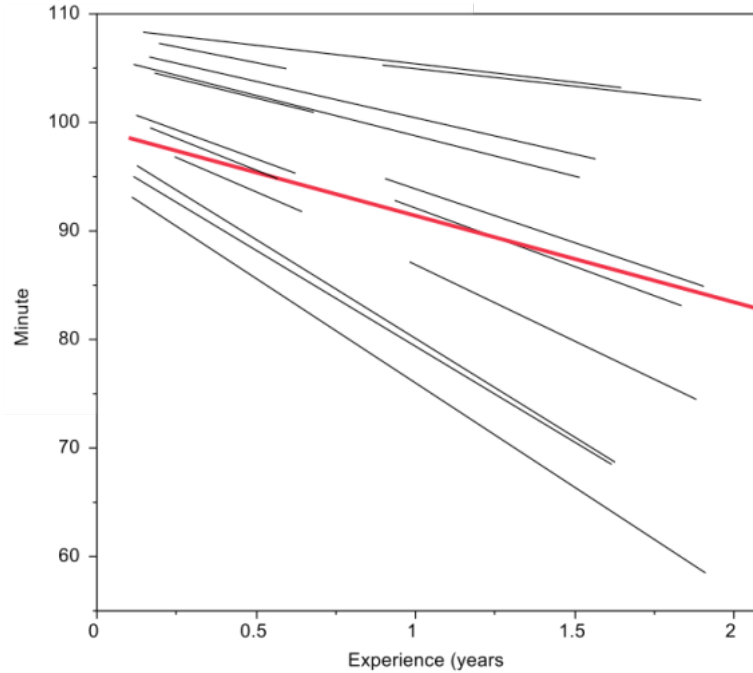
Figure 1 shows the relationship between experience as expressed in years and average procedure time. Using a multiple regression analysis, the trend shows a linear decrease in procedure times from .5 years of experience to 4 years of experience. The red line shows the average trend. After the four-year mark, the average trend seems to plateau.

Figure 2. Procedure Time by Experience Groups



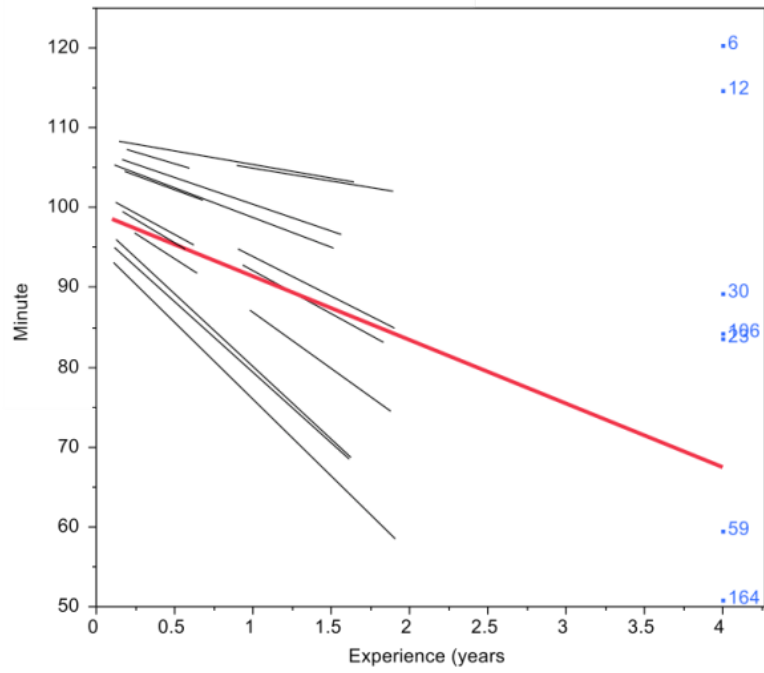
Using a random-coefficient model, the data also showed linear trends in procedure time based on the operator's years of experience. In Figure 2, the red line has 2 coefficients: an intercept and a slope. Each black line is one of the 17 residents from the database. The beginning and the ending of each line illustrate the range of experience for each resident. In summary, residents gain greater proficiency on procedures in the operating room on the average of 9.06 minutes per year with a 95% confidence interval from 2.19 minutes to 15.9 minutes.

Figure 3. Learning Curve (Residents)



This level of analysis also included faculty data and revealed variation among faculty as well. The equivalent plot for all five faculty members included in the study is illustrated in Figure 3. Each black line is one of 17 residents from the database. The blue dots are each faculty member and the numbers next to the dots are the numbers of surgeries in the database for each of the faculty members. The two faculty members with over 100 surgeries have the strongest impact on the time trend.

Figure 4. Learning Curve (Faculty and Residents)



DISCUSSION

Main Findings

The median procedure time was 75 minutes (range= 1 to 517 minutes). Multiple regression indicated that for the average patient, a faculty member took 63.8 minutes (95% CI = 60.8 to 66.7 minutes) and a resident took 81.9 minutes (95% CI = 78.7 to 85.0 minutes, $P < .0001$). Further, residents gain greater proficiency on procedures in the operating room on the average of 9.06 minutes per year with a 95% confidence interval from 2.19 minutes to 15.9 minutes. These results demonstrate that the appropriate scheduling of operating room should take into consideration the experience level of the dental operator.

Support From Previous Research

A study by Forsyth et al described the operating room time for pediatric dental procedures performed under general anesthesia at a regional children's hospital over a two-year period.¹⁰ A cross sectional review of pediatric dental general anesthesia records for 709 patients and utilization of operating room time was analyzed. This current study supports the Forsyth et al study in concluding that, although learning in the operating room is a highly valuable experience for pediatric dental residents, the level of the dental operator is one key variable in determining operating room time needed in pediatric dental rehabilitation under general anesthesia.

Limitations of Current Study

I acknowledge multiple limitations inherent in this current study. Foremost, this study is limited due to its retrospective design. Additionally, patients were not randomized to different resident-level groups. Finally, I was unable to rule out other factors that varied between operator groups. For example when a resident had difficulty performing a procedure, faculty would have been more likely to perform a greater portion of the operation. This scenario is likely to occur when a resident is involved because of minimal experience. These circumstances were unaccounted for in my analysis.

Clinical Implications

An ideal operating room scheduling plan at teaching hospitals includes distribution of pediatric dental surgeries among both faculty and residents based on opportunities for the former to maintain skills and generate departmental revenue as well as for the latter to acquire experience. For residents, opportunities to learn dental rehabilitation techniques in the operating room are highly valuable. However, these opportunities should be allocated in such a way that minimizes operating room idle time and overruns. With the results of this study, the VCU Department of Pediatric Dentistry can more accurately schedule operative time for faculty and two levels of residents.

In terms of future research directions, this retrospective study could be used to clarify the hypothesis for future studies, determine an appropriate sample size, and identify feasibility issues for a prospective study. Future research may include a direct analysis of pediatric dental patient operating room cost between resident and faculty operator. Also interesting would be a direct analysis of complication rates between

resident levels and faculty or an analysis of changes in surgical time per resident case conducted as training level progresses.

CONCLUSIONS

In conclusion, resident involvement in the operating room leads to longer procedure times and additional system cost particularly for cases involving junior level residents. Although operating room time is a necessary, innate, and crucial component in pediatric dental training, procedure times and associated costs should be acknowledged. This study concludes that pediatric dental operating room planning and scheduling in teaching hospitals should take into account real constraints such as residents' level of training and skill.

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