

# Orthognathic cases: what are the surgical costs?

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**SUMMARY** This multicentre, retrospective, study assessed the cost, and factors influencing the cost, of combined orthodontic and surgical treatment for dentofacial deformity. The sample, from a single region in England, comprised 352 subjects treated in 11 hospital orthodontic units who underwent orthognathic surgery between 1 January 1995 and 31 March 2000. Statistical analysis of the data was undertaken using non-parametric tests (Spearman and Wilcoxon signed rank).

The average total treatment cost for the tax year from 6 April 2000 to 5 April 2001 was €6360.19, with costs ranging from €3835.90 to €12 150.55. The average operating theatre cost was €2189.54 and the average inpatient care (including the cost of the intensive care unit and ward stay) was €1455.20. Joint clinic costs comprised, on average, 10 per cent of the total cost, whereas appointments in other specialities, apart from orthodontics, comprised 2 per cent of the total costs.

Differences in the observed costings between the units were unexplained but may reflect surgical difficulties, differences in clinical practice, or efficiency of patient care. These indicators need to be considered in future outcome studies for orthognathic patients.

## Introduction

There is good preliminary evidence that referrals to hospital departments are becoming increasingly more complex as orthodontic specialist practitioners are undertaking an increasing workload. This includes cases that need complex management and treatment by oral and maxillo-facial surgeons and orthodontists (Russell *et al.*, 1999). The majority of orthognathic cases in the United Kingdom (UK) are the remit of the hospital-based service. If demand for this service increases in line with orthodontics within the General Dental Service, which has doubled over the past 5 years, then the health care burden will be significant and will need to be planned (Department of Health, 2000). Precisely how large this potential burden is likely to be has not been quantified in the UK, but studies in the United States of America (USA) suggest that within their population, 1.5 million people have malocclusions severe enough to require orthognathic surgery (Bailey *et al.*, 1999). If this were extrapolated to the UK, a conservative estimate would suggest that 250 000 such patients exist. Currently, demand is unlikely to produce such a figure, but with heightened awareness within the general population, it is clear this workload for consultants is going to increase and this will require careful planning and costing. With this in mind, it is entirely reasonable to examine the benefits of orthognathic correction in the context of other health care demands and it would seem appropriate to ask questions about the costs of such treatment.

A cost-utility analysis by Cunningham *et al.* (2003), using quality-adjusted life years on a small sample of orthognathic

patients, has suggested that orthognathic treatment provides good outcomes at relatively low cost. Other work investigating the costs of the orthodontic treatment in relation to orthognathic surgery indicates it is a relatively inexpensive component of such complex multidisciplinary treatment (Richmond *et al.*, 2004; Kumar *et al.*, 2006).

The aim of this study was, therefore, to perform a cost description analysis on a large sample of patients treated within the South West Region of the UK and to calculate the direct health service costs relating to the surgical aspects of orthognathic treatment.

## Materials and methods

Four hundred and eighty-nine subjects were originally identified for the investigation although 137 patients were subsequently excluded mainly because their surgery dates were outside the limits set for the study. In total, 11 hospital units in the South West region were included. Although the orthodontic treatment was performed in 11 units, orthognathic surgery was undertaken in only nine. Data on this study have been published previously (Kumar *et al.*, 2006).

### Identification of subjects

Inclusion criteria required the treatment to have involved both orthodontics and surgery, with the latter having been performed between 1 January 1995 and 31 March 2000. Subjects were excluded if their dentofacial deformity was associated with oro-facial clefting or with a recognized oro-facial syndrome.

### *Operating theatres*

The staff overheads and capital costs of surgery were based on the duration of the osteotomy procedure. This was derived from the anaesthetic start and end times recorded in the anaesthetic chart. The grade of main surgeon, assistant surgeon, and the type of surgery performed, with details of fixation type used, were also noted. The surgical movements and additional procedures performed for each patient were recorded as well as complications, before, during, and after surgery.

### *Ward costs*

Ward admission and discharge dates at the time of surgery together with costs per bed day were used to calculate ward costs. In a similar way, the duration and, therefore, cost of any admission to an intensive care or high dependency unit could be calculated from admission and discharge dates.

### *Theatre consumable costs*

The number and types of surgical sets used during surgery were established from operating theatre staff. Costs, including an amount for wear and tear with future replacement, were obtained from the central sterilization department at the same unit. Expensive items, such as fixation plates and screws, were excluded from this list and were calculated separately according to the type of surgery performed for each individual subject.

### *Consumables*

Consumables were identified as being any product or item whose use during treatment invoked a cost due to recycling or replacement. Consumables, therefore, included replaceable items such as radiographs, gloves, information leaflets, and items that could be recycled such as instruments.

### *Capital and overhead costs*

Detailed departmental capital and overhead costs for orthodontic, oral and maxillo-facial surgery, and theatres were obtained from the finance division of the one hospital unit and these figures were used to establish estimated costs for each unit in the study.

### *Staff costs*

Staff cost calculations for clinicians were based on the operator grades and generic national pay scales. Data were collected to establish numbers and grades of staff present in outpatient clinics and theatres other than the main clinician. In addition, the duration in minutes of each type of outpatient appointment such as those for joint clinics and preparation for surgical wafers was recorded. Information was collected for each hospital unit by meeting or conducting telephone

interviews with personnel. Calculations took into account the fact that some appointments were longer than others and thus incurred higher staff overheads and capital costs.

### *Error study on the reliability of data collection and calculations*

The reliability of data collection was assessed by examining 30 sets of patient records on two separate occasions and by focussing on 15 specific parameters including: the number of pre-surgical appointments, operator grade, and start malocclusion. Transcription and calculation errors were minimized by repeated checking of formulae, transferring data to two separate spreadsheets for cross-checking, and by asking another researcher to recalculate the results using the calculation formulae.

## **Results**

The total number of subjects in this study comprised 109 males and 243 females. Their ages ranged from 14 to 57 years. Total treatment costs, including both orthodontics and surgery, were calculated for 352 subjects and have been previously reported (Kumar *et al.*, 2006), but briefly, the average cost for the tax year from 6 April 2000 to 5 April 2001 was €6293.72. The costs ranged from €3796.66 to €12 010.03.

In the error study, 15 parameters were re-examined to establish the reliability of the study method. All the parameters showed high levels of agreement. These were analysed using non-parametric tests (Spearman and Wilcoxon signed rank). Spearman's correlation coefficient showed that for treatment length, both original and re-examined data correlated well. The Wilcoxon test showed that differences between both sets of data were insignificant.

### *Outpatient costs*

Outpatient costs were established for all 352 subjects. The average cost for the total number of outpatient appointments in the oral and maxillo-facial surgery department, excluding joint clinics, was €158.14 per subject. Routine orthodontic costs on average comprised 25 per cent of the total treatment cost. Joint clinic costs comprised, on average, 10 per cent of the total, appointments in other specialities, apart from orthodontics, 2 per cent, and laboratory costs 4 per cent.

### *Inpatient costs*

Inpatient costs were obtained for 352 subjects. The ward cost per bed day was €253.94 and the intensive care cost per bed day €1959.51. The average ward stay cost per subject was €1299.31 and accounted for approximately 20 per cent of the total treatment cost (Table 1).

**Table 1** The influence of admission of subjects to an intensive care unit. Selected costs are shown.

	Costs in Euros, median (range)		Mann–Whitney <i>U</i> -test
	Admission to intensive care unit ( <i>n</i> =23)	No admission to intensive care unit ( <i>n</i> =329)	<i>P</i> value
Appointments in other specialities	236.08 (00.00–613.81)	94.43 (00.00–1085.98)	0.001
Ward stay	1777.64 (1015.80–2285.54)	1269.74 (507.90–3809.23)	<0.001
Operating theatre staff overhead and capital costs	1262.30 (449.60–2741.37)	851.44 (232.22–2734.91)	<0.001
Operating theatre consumables	1330.39 (558.32–1849.53)	1330.39 (553.70–1849.53)	0.399
Operating theatre total	2711.37 (1244.85–4071.77)	2032.79 (904.90–4584.43)	0.002
Total treatment cost	9759.12 (6538.85–12 010.03)	6022.59 (3796.66–11 950.48)	<0.001

### Operating theatre costs

The average operating theatre cost was €2189.54, which represented 35 per cent of the total treatment cost. Staff overhead and capital costs in theatres were on average €965.20, whereas the cost of consumables was €1224.33. Descriptive statistics for theatre costs are shown in Table 2 and the percentages illustrated in Figure 1. Theatre consumable costs were found to be significantly higher than staff overhead and capital costs ( $P < 0.001$ ). Surgical fixation costs were found to be significantly higher than the cost of other consumables used during the surgical procedure ( $P < 0.001$ ).

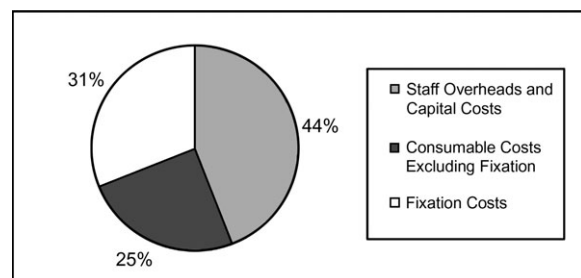
### Influence of surgery type on cost

**Comparison of single jaw and bimaxillary surgery.** One hundred and ninety-one patients had single jaw surgery and 161 bimaxillary surgery. The average total treatment cost was €5445.97 for subjects who had single jaw surgery (Table 3) and €7444.77 for those who had bimaxillary surgery. Total treatment costs were significantly higher for subjects who underwent bimaxillary surgery ( $P < 0.001$ ). Bimaxillary surgery was associated with significantly higher costs than single jaw surgery in all in- and outpatient operating theatre settings.

**Comparison of single jaw surgery.** Of the 191 subjects who had single jaw surgery, 56 had maxillary and 135 mandibular procedures. The average total treatment cost for subjects who underwent maxillary surgery was €5733.06. The cost for mandibular surgery was on average €5326.85. The costs associated with treatment are shown in Table 3. Total treatment costs and operating theatre costs were significantly higher for treatments involving maxillary surgery only ( $P = 0.047$  and  $P < 0.001$  respectively), which was due to a significantly higher cost of consumables used during maxillary surgery ( $P < 0.001$ ). There was no significant difference in operating theatre staff overheads and capital cost for subjects who had maxillary or mandibular surgery ( $P = 0.087$ ).

### Influence of start malocclusion on cost

The influence of the start malocclusion on cost was determined by separating malocclusions into antero-posterior and vertical relationship categories. Of the 352 subjects in the study, 11 had a Class I, 188 a Class II, and 153 a Class III malocclusion. Total treatment costs for patients with a Class III malocclusion were significantly higher than those for subjects with a Class II malocclusion. The Kruskal–Wallis *H*-test was used to assess differences in costs between all three malocclusion groups as a whole. As subjects were categorized into three Classes of malocclusion, the Mann–Whitney *U*-test was also used to assess cost differences between pairs of malocclusion Class. Operating theatre costs were highest for subjects with Class III and lowest for those with Class II malocclusions ( $P < 0.001$ ). Sixty-four per cent of Class III malocclusions required a bimaxillary osteotomy compared with only 31 per cent of Class II malocclusions. The operating theatre cost for subjects with Class I malocclusions was significantly higher than those with Class II malocclusions ( $P = 0.037$ ) but not significantly lower than the cost for those with Class III malocclusions ( $P = 0.541$ ). All Class I malocclusion subjects required bimaxillary surgery. The costs and Kruskal–Wallis *H*-test results are detailed in Table 4.



**Figure 1** Pie chart showing the percentage contribution of operating theatre staff overheads and capital costs, and the categories of theatre consumable costs to total operating theatre costs.

**Table 2** Descriptive statistics of theatre costs for 352 subjects. The contributions of staff overhead, capital, and consumable costs to total theatre costs are shown.

	Staff, overhead and capital cost	Fixation costs	Consumable costs excluding fixation costs	Total consumable costs	Total theatre costs
	A (€)	B (€)	C (€)	B+C (€)	A+B+C (€)
Median	883.41	804.38	526.01	1330.39	2084.88
Minimum	232.21	27.69	526.01	553.70	904.90
Maximum	2741.37	1087.77	761.77	1849.52	4584.43
Range	2509.17	1060.08	235.76	1295.81	3679.52
Interquartile range	602.83–1236.26	283.39–1087.77	526.01–526.01	809.40–1613.78	1538.27–2729.82

The determinants of total operating theatre cost have been designated A, B, and C to illustrate how costs have been combined during the study.

**Table 3** Differences in costs between subjects treated by maxillary or mandibular surgery only for outpatient, inpatient, and operating theatre settings.

	Costs in Euros, median (range)		Mann–Whitney <i>U</i> -test
	Surgery type: maxillary surgery only ( <i>n</i> = 56)	Surgery type: mandibular surgery only ( <i>n</i> = 135)	<i>P</i> value
Ward stay	1015.80 (507.90–2031.58)	1015.80 (507.90–2539.48)	0.201
Intensive care unit	00.00 (00.00–3919.02)	00.00 (00.00–1959.51)	0.253
Operating theatre staff overhead capital	593.42 (301.03–1444.84)	645.02 (232.22–2193.08)	0.087
Operating theatre consumables	1330.39 (553.70–1566.15)	550.61 (558.32–1045.14)	<0.001
Operating theatre total	1916.13 (904.90–2959.40)	1454.41 (1041.60–3021.88)	<0.001
Total treatment cost	5481.23 (4035.18–10 548.57)	5227.67 (3835.89–8638.51)	0.047

### Vertical relationships

The subjects were divided into groups, according to whether they had a normal overbite, a deep overbite, or an anterior open bite (AOB). Within the sample, 276 subjects had a normal overbite, 53 an AOB, and 23 a deep overbite. The average total treatment cost for subjects with a normal overbite, an AOB, and a deep overbite have been previously reported (Kumar *et al.*, 2006). The total treatment costs for subjects with an AOB were significantly higher than for those with a deep bite ( $P = 0.002$ ), and a normal overbite cost significantly more to treat than a deep bite malocclusion ( $P = 0.009$ ). Operating theatre costs were highest for subjects with an AOB and lowest for those with a deep bite ( $P < 0.001$ ; Table 5).

### Influence of operator grade

Consultant grade operators performed the surgery in 280 subjects. The 72 remaining subjects had their surgery performed by non-consultant grade operators. For a consultant grade operator, the average total treatment cost was €6373.31 and for a non-consultant grade operator €5992.37. Total operating theatre costs were, on average, €2246.32 for patients operated on by a consultant and €1968.67 for subjects operated on by non-consultant grades.

Of the more complex bimaxillary surgery, 83.4 per cent was performed by consultants and only 16.6 per cent by non-consultant grades. Significant differences were found only for the cost of joint clinic appointments and for theatre costs (Table 6). Total treatment cost was not found to be significantly different between consultant and non-consultant surgical operators ( $P = 0.441$ ). The total cost of joint clinic appointments was found to be significantly higher when non-consultant grades ( $P = 0.003$ ) performed surgery. Interestingly the median costs were identical but the range was much greater in the consultant group. The operating theatre cost was significantly higher for consultants ( $P = 0.002$ ). This was because consumable costs, staff overheads, and capital costs were significantly higher for consultants in operating theatres ( $P = 0.034$  and  $P = 0.001$ ). Interestingly, there was no significant difference in the duration of surgery between consultant and non-consultant surgical operators ( $P = 0.217$ ).

### Influence of complications on cost

Out of the 352 subjects included in the study, 164 experienced complications at some stage during treatment. Of these, 41 experienced complications during surgery such as

**Table 4** Differences in costs according to the Class of antero-posterior malocclusion. Costs for inpatient and operating theatre settings are shown.

	Cost in Euros, median (range)			Kruskal–Wallis <i>H</i> -test
	Malocclusion: Class I ( <i>n</i> = 11)	Malocclusion: Class II ( <i>n</i> = 188)	Malocclusion: Class III ( <i>n</i> = 153)	<i>P</i> value
Ward stay	1015.80 (761.84–2031.58)	1269.74 (507.90–2539.48)	1269.74 (507.90–3809.22)	0.269
Intensive care unit	00.00 (00.00–3919.02)	00.00 (00.00–3919.02)	00.00 (00.00–3919.02)	0.801
Operating theatre staff overhead capital	839.83 (501.71–1238.04)	809.80 (335.41–2218.88)	994.65 (232.22–2741.37)	0.047
Operating theatre consumables	1330.39 (1330.39–1613.78)	809.40 (553.70–1849.52)	1613.78 (558.32–1849.52)	<0.001
Operating theatre total	2170.23 (1851.51–2851.81)	1738.23 (904.90–3862.00)	2542.61 (1041.60–4584.43)	<0.001
Total treatment cost	5948.03 (4116.00–9806.62)	5854.25 (3912.93–10548.57)	6424.40 (3835.90–12 150.55)	0.002

**Table 5** Differences in costs according to the type of vertical malocclusion. Costs for outpatient, inpatient, and operating theatre settings are shown.

	Cost in Euros, median (range)			Kruskal–Wallis <i>H</i> -test
	Malocclusion: normal ( <i>n</i> = 276)	Malocclusion: anterior open bite ( <i>n</i> = 53)	Malocclusion: deep bite ( <i>n</i> = 23)	<i>P</i> value
Ward stay	1269.74 (507.90–3809.23)	1269.74 (761.84–2539.48)	1015.80 (761.84–2031.58)	0.745
Intensive care unit	00.00 (00.00–3919.02)	00.00 (00.00–3919.02)	00.00 (00.00–00.00)	0.417
Operating theatre staff overhead capital	895.19 (232.22–2741.31)	980.43 (301.03–2012.47)	619.22 (351.20–2218.88)	0.062
Operating theatre consumables	1330.39 (558.32–1849.53)	1349.80 (558.32–1849.52)	809.40 (553.70–1849.52)	<0.0001
Operating theatre total	2062.51 (1041.60–4584.43)	2421.06 (1361.28–3862.00)	1428.62 (904.90–3832.66)	<0.0001

**Table 6** A comparison of costs for subjects treated by consultant and non-consultant surgical operators. A selection of costs operating theatre, outpatient, and total treatment costs are shown.

	Cost in Euros, median (range)		Mann–Whitney <i>U</i> -test
	Consultant ( <i>n</i> = 280)	Non-consultant ( <i>n</i> = 72)	<i>P</i> value
Joint clinic appointments	648.78 (00.00–1946.35)	648.78 (324.40–1459.77)	0.003
Operating theatre staff overhead and capital	941.05 (232.21–2741.37)	721.46 (360.24–2734.91)	0.001
Operating theatre consumables	1330.39 (553.70–1849.52)	1045.14 (558.32–1849.52)	0.034
Operating theatre total	2331.58 (904.02–4071.77)	1812.11 (1169.62–4584.43)	0.002
Total treatment cost	6184.79 (3835.89–12 150.55)	6096.85 (4288.20–11 950.48)	0.441

unexpected osteotomy split or blood loss, 87 in the immediate post-surgery period, such as a prolonged recovery following anaesthesia, poor final occlusion/jaw positioning, and lip parasthaesia, and 100 suffered long-term complications including parasthaesia, infected bone plates, and deviated nasal septum. Some patients experienced more than one complication. The average total treatment cost for subjects who experienced complications was €6815.94, whereas the cost for those who did not experience complications was €5962.61. The average ward stay costs were €1421.49 and €1295.64, respectively.

Not surprisingly, subjects who experienced complications, in general incurred significantly higher costs in all areas of treatment than those without complications (Table 7). As might be expected, the higher total operating theatre cost for subjects who experienced complications was related to significantly higher staff overheads and capital cost in the operating theatre ( $P < 0.001$ ).

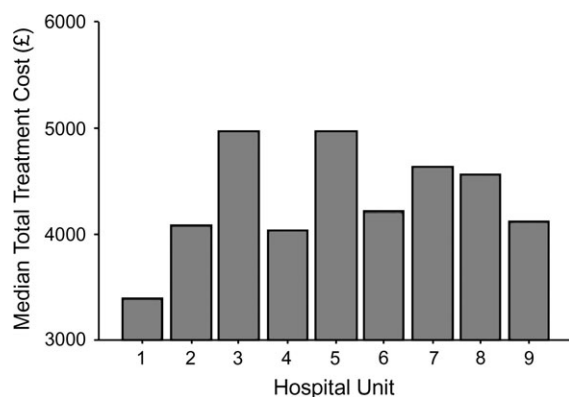
#### *Variation of costs between different hospital units*

Total treatment cost varied according to the unit in which the subjects were treated. The average total treatment cost



**Table 7** The influence of complications outpatient, inpatient, and operating theatre on costs.

	Cost in Euros, median (range)		Mann–Whitney <i>U</i> -test
	No complications ( <i>n</i> = 188)	Complications ( <i>n</i> = 164)	<i>P</i> value
Ward stay	1015.80 (507.90–2031.58)	1269.74 (507.90–3809.23)	<0.001
Intensive care unit	00.00 (00.00–3919.02)	00.00 (00.00–3919.02)	0.025
Operating theatre staff overhead capital	239.23 (232.22–2193.08)	1006.32 (351.20–2741.31)	<0.001
Operating theatre consumables	1330.39 (558.32–1849.52)	1330.39 (553.70–1849.52)	0.472
Operating theatre total	1938.28 (1041.60–3736.13)	2338.73 (904.90–4584.43)	0.040
Total treatment cost	5811.60 (3835.90–12 150.55)	6564.02 (4035.18–11 905.48)	<0.001

**Figure 2** Bar chart comparing median total treatment cost in Euros for hospital units 1–9 undertaking the orthognathic surgery.

ranged from €5312.26 to €7798.50 between units. Total treatment costs for subjects in different units are shown in Table 8 and presented graphically in Figure 2.

Total treatment cost differences between the cheapest and most expensive units were statistically significant ( $P < 0.001$ ). Subjects in unit 1 had the lowest median total treatment cost whereas those in units 3 and 5 shared the highest cost. The reasons for the higher total treatment costs in units 3 and 5 were different. Subjects in unit 3 had significantly higher intensive care unit, ward stay, and total operating theatre costs than those in unit 1 (all  $P < 0.001$ ). The subjects in unit 5 also had higher ward stay and total operating theatre costs than those in unit 1 but did not have a significantly higher intensive care unit cost ( $P = 0.105$ ). For subjects in unit 3, total costs in all outpatient areas, apart from for routine orthodontic appointments, were significantly higher than those in unit 1 (all  $P < 0.001$ ). However, in unit 5 only the total costs of emergency appointments, appointments in other specialities, and laboratory items were significantly higher ( $P < 0.0001$ ).

## Discussion

The overall aim of this study was to establish the total direct health service costs of combined orthodontic and surgical treatment for the treatment of dentofacial deformities. As

such it is no more than a detailed microcosting exercise but, nevertheless, provides important information for health care providers and planners. Most costing studies on orthognathic care have investigated costs for surgical procedures without considering orthodontic, direct or indirect, costs (Lombardo *et al.*, 1994; Dolan and White, 1996; Blakey and White, 1999). Lombardo *et al.* (1994) reported that the costs of Le Fort I and bilateral sagittal split osteotomies (BSSO) and average patient charges ranged from \$4778 to \$8816 for bimaxillary osteotomies, \$3538 to \$6784 for Le Fort I osteotomies, and \$3086 to \$5023 for BSSO. Not surprisingly, bimaxillary surgery was associated with the highest hospital charges and mandibular surgery with the lowest. The figures were based on patient charges and these may not reflect the true cost of providing treatment. Clearly surgical costs can influence the cost of treatment for patients with dentofacial deformities, but the outpatient costs which relate to orthodontic treatment should not be underestimated.

In the present study, a number of assumptions have been made and there is potential for inaccuracy on a number of issues. These have all been previously discussed by Kumar *et al.* (2006). However, the aim was to determine the true surgical cost to a publicly funded health service.

## Operating theatre costs

In the past, costing studies have emphasized the importance of the operating theatre cost. The study by Lombardo *et al.* (1994) based in the USA investigated the surgical costs of osteotomies but did not include outpatient costs. They found that in 1992, operating theatre costs accounted for 80 per cent of total charges, whereas the 'room charge' accounted for only 20 per cent. In another USA study, investigating hospital charges for orthognathic surgery, the operation cost comprised 76 per cent and the inpatient charges 24 per cent of the hospital bill (Dolan and White, 1996). In the present investigation, the operating theatre cost comprised 60 per cent of the total treatment cost when outpatient costs were excluded. This is a lower proportion when compared with the studies in the USA. However, comparison of the costs in the present research with those from the quoted studies is difficult. This is because charges in the USA represent the

**Table 8** Total treatment cost in Euros differences between hospital units 1–9.

	Hospital unit								
	1	2	3	4	5	6	7	8	9
Number of subjects	84	78	35	36	32	28	31	16	12
Median cost	4993.24	5995.82	7295.39	5924.10	7294.57	6184.79	6802.76	6700.35	6058.31
Minimum cost	3835.89	4288.20	5347.02	4591.27	4855.48	4748.13	4851.13	4227.41	4116.00
Maximum cost	7351.48	9312.39	12 150.55	8581.80	11 016.09	11 950.48	8679.38	10 504.53	11 838.65
Cost range	3515.59	5024.20	6803.53	3990.54	6160.61	7202.35	3828.25	6277.14	7722.65

cost to the patient, which may not be the same as the actual cost of providing treatment. In the present study, the staff capital and overhead costs on average accounted for 44 per cent of the total theatre cost and approximately 15 per cent of the total treatment cost. It is therefore tempting to think that staffing costs are less important than operating theatre consumable costs, which comprised 20 per cent of the total treatment cost. However, regression analysis revealed that the duration of surgery accounted for 55 per cent of the variation in total treatment cost. The duration of surgery directly affects the operating theatre staff overheads and capital costs. Therefore, control of the duration of the surgical procedure may be important in the control of treatment costs for orthognathic procedures. Since studies have generally concentrated on the comparison of operating theatre with ward stay costs, the influence of the duration of surgery has not been previously highlighted. Lombardo *et al.* (1994) found that operating theatre costs increased between 1985 and 1992, but the increase was a result of the rising cost of surgical supplies and that 'surgeons minimally influence charges attendant to the operating theatre'. They suggested that fixation costs had a greater influence on treatment costs than surgeon costs. In the present study, the fixation cost comprised 31 per cent of the total operating theatre cost and 56 per cent of the cost of consumables in the operating theatre. The extensive use of semi-rigid or rigid fixation using expensive surgical plates and screws no doubt contributed to this. Most surgeons are well aware of the high cost of these items and careful use is required if costs are to be controlled.

#### *Inpatient costs*

In the present study, inpatient costs contributed less to total treatment cost than routine orthodontic costs. Collectively, the length of stay in intensive care and in the ward accounted for 28 per cent of the variation in total treatment cost. The length of stay in intensive care itself accounted for 20 per cent of the variation. The highest total treatment costs were for subjects who were admitted to an intensive care unit. Data were not collected relating to the reasons for admission to intensive care. Clearly altering the length of stay in hospital has a significant influence on total treatment cost. This is in contrast to other studies, which state that benefits

of cost reduction are over emphasized because costs attributable to the last days of a hospital stay are an insignificant component of total cost (Taheri *et al.*, 2000).

The aim should be for all patients undergoing orthognathic treatment to have a minimal stay in hospital. Studies promoting outpatient orthognathic surgery claim that the reduction in ward stay considerably reduces costs and that few unexpected complications occur (Lupori *et al.*, 1997). If the length of ward stay is to be reduced in an attempt to cut costs, implications on patient health must be considered. Airway management following osteotomy procedures is of importance and will influence the length of hospital stay. Haber-Cohen and Rothman (1988) found a respiratory complication rate of only 0.38 per cent following osteotomy procedures. Lupori *et al.* (1997) reported that no patients had major airway complications over a 7-year period and felt that orthognathic procedures could be performed safely and efficiently on an outpatient basis.

Post-operative bleeding following Le Fort I osteotomies is a recognized concern and may increase with shortened ward stays (Hemmig *et al.*, 1987; Solomons and Blumgart, 1988). Transfusions are not usually required with orthognathic surgery and the risks of bleeding are low, but when bleeding does occur the consequences may be severe (Samman *et al.*, 1996). The decision on when to discharge a patient needs to be made by clinicians, based on the clinical status of the patient and not on cost.

#### *Factors influencing cost*

The final aim of the research was to assess the factors that influence the cost of combined orthodontic and surgical treatment for the treatment of dentofacial deformities. The findings show that there were significant differences in operating theatre costs between subjects who had bimaxillary surgery and single jaw surgery and therefore the presenting malocclusion has an effect. A larger number of Class I and Class III malocclusion subjects required bimaxillary surgery. This more complex bimaxillary surgery was associated with the highest cost, and more straightforward mandibular surgery alone was associated with the lowest cost. This agrees with the findings of Lombardo *et al.* (1994). The present study also considered total treatment costs, outpatient, and inpatient costs in relation to the type

of surgery performed. The findings suggest that in general, bimaxillary surgery is associated with significantly higher costs in both outpatient and inpatient hospital settings. This is not unexpected in view of the increased complexity in planning and executing bimaxillary treatment. These results may well be useful for resource planning in hospital units.

### *Complications*

Complications occurring at any stage during treatment were associated with a higher total treatment cost and in addition, higher costs occurred in outpatient, inpatient, and operating theatre settings. The complications in this study were assessed in relation to the date of surgery and were classed as either occurring during surgery, immediately after surgery, or long term. Complications that occurred included bleeding, infections, and parasthaesia. Complications also occurred due to inadequate fixation, which resulted in the need for further surgery in the post-operative period. Higher costs have been found in association with complications following the treatment of mandibular fractures (Dodson and Pfeffe, 1995). The results of the present study are in agreement with those findings that the costs of complications were likely to have been underestimated if only additional outpatient appointments were included in the cost assessment. Data on additional surgical procedures and any related ward stays related to complications were not collected. The true cost due to complications was not, therefore, calculated in this study and the inclusion of more data in future investigations would be useful.

### *The grade of surgical operator*

Operating theatre costs were higher for subjects whose operation was performed by a consultant. Analysis of the data suggests that the higher operating theatre costs for consultant surgeons related partly to their salary but also to consultants performing far more complex bimaxillary operations. These not only take longer to perform but require the use of more high cost consumables. Non-consultant grades performed the simpler more straightforward single jaw operations.

### *Location of treatment*

A large variation in total treatment cost was found between hospital units participating in this study. Higher costs for the ward stay and in the operating theatre were common to both of the most expensive units, when compared with the least expensive unit. The length of ward stay ranged from 2 to 15 days in one case.

However, the costs in the most expensive units also differed. For example, subjects in unit 3 had significantly higher intensive care unit costs than those in unit 5 ( $P = 0.003$ ). The maximum length of stay in intensive care, when it occurred, was 2 days. It is tempting to suggest reasons for

the difference in costs between hospital units, but in view of the lack of information on treatment outcomes it is impossible to make true comparisons between hospital units.

The design of the study meant that it was not possible to match the groups used for comparison. Therefore, confounding factors may have influenced the findings from this part of the investigation. Although it is difficult to draw firm conclusions, the results are interesting and may be used as a framework on which future research can be based.

## **Conclusion**

This study, an extension of a previously reported microcosting investigation (Kumar *et al.*, 2006) on orthognathic subjects, deals more specifically with the surgical costs. The data indicate a relatively inexpensive surgical care pathway for orthognathic patients, which is predominantly influenced by the type of surgery and length of the inpatient hospital stay. It was noted that there were median cost variations between the surgical units involved in the study. These have not been fully explained but may indicate differences in the process of care for these patients. Future costing studies might consider the importance of these differences in the design and structure of research protocols.

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## **Acknowledgements**

We are grateful to all the consultants in the South West Region who gave permission for access to their records, to the nurses, secretaries, receptionists, and laboratory staff at the Orthodontic Department at Derriford Hospital, Plymouth for help during the long period of data collection, Brian Jones and his team in the Finance Department for work on the hospital accounts and Steve Shaw at the University of Plymouth for statistical advice in relation to this project.

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