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Cutaneous laser surgery for secondary burn reconstruction: Cost benefit analysis

Ernest A. Azzopardi [a,b,c,g,*], *Robert T. Duncan* [b], *Mollie Kearns* [f], *Francesco Marangoni* [e], *Nader Ibrahim* [b], *Ernest A.F. Azzopardi* [d], *Dean Boyce* [b,g], *Matteo Tretti* [h,1], *Maxwell S.C. Mursion* [a,b,1]

[a] *The Welsh Laser Centre, the R&D Dept, Swansea Bay University Health Board Swansea, Wales, UK*
[b] *Welsh Centre for Burns and Plastic Surgery Wales, UK*
[c] *BAPRAS Fellow, Cadogan Clinic, Sloane Street, London, UK*
[d] *University of Malta, G F Abela College, Economics Department, University of Malta, Malta*
[e] *Eufoton, Via Flavia, Trieste, Italy*
[f] *Clinical Management Unit, ABM ULHB Morriston Hospital, Swansea, UK*
[g] *Swansea University Medical School, Wales, UK*
[h] *Laserplast SrL StP, Piazza Elenora Duze 2, Milan, Italy*

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ABSTRACT

Thermal disease presents a major burden to individual patient morbidity, healthcare cost as well as to over all economy. Burns also also represent a significant per-patient utlilisation of finite healthcare resources. Secondary complications in these patients, such as multiple drug resistant organisms, may have a devastating effect.

Laser surgery has recently come of age as an optimal tool in the secondary reconstruction of burn injury, that is able to simultaneously address significant sheet scar tightness, hypertrophic, atrophic, and keloid complications, pruritus, microstomia, ectropion, skin graft honeycombing, and improve range of movement whilst reducing the risk of infection to <1%. Yet, cutaneous laser surgery is often underutilised due to the perceived concerns about the sustainability of a new service with relatively high startup cost. We present a dual methodology to explore this concern: an evidence-based background review of the last 5 years of current best evidence, and a 22-year cost-analysis comparison at an established, high volume UK Centre of reconstructive surgery.

We report that fiscal viability for laser surgery services for secondary burn reconstruction is supported by: level 2 (one systematic review) level 4 evidence (2 studies) and level 5 evidence (expert reports). Evidence over 22 years from an established super-regional NHS laser centre shows that introduction of this service led to sustained and substantial cost saving, producing excellent surgical results at a fraction of the cost of traditional surgery.

Analysis of the potential dollar-effect of these advantages to the general population supports state investment in expertise and capital equipment as a medium to long-term cost saving strategy, which may also aid re-integrating patients into the workforce making a meaningful contribution to the economy.

* *Corresponding author at*: The Welsh Laser Centre, Swansea Bay University Health Board, NHS Wales, Morriston Hospital, Maes Egwlys, Swansea SA66 NL, UK.
E-mail address: ernet.azzopardi@wales.nhs.uk (E.A. Azzopardi).
[1] Joint contribution as senior authors.
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1. Background

Thermal disease presents a major burden to individual patient morbidity, healthcare cost as well as over all economy [1]. Burns also also represent a significant per-person utlilisation of finite healthcare resources [2]. Secondary complications in these patients, such as multiple drug resistant organisms, may have a devastating effect [3]. Indirect cost to the economy, in terms of labour force, missed employment and social security resource utilisation may be substantial although difficult to quantify.

Cutaneous, reconstructive laser surgery has, over the past 22 years, come of age and in expert hands is associated with substantial improvement in quality of the scars, range of movement, supplenes, and a reduction in pruritus, tightness [4,5] as well as in the management of specific complications like epiphora, ectropion, microstomia, hypertrophic and atrophic burn scarring, and in the management of iatrogenic complications [6–8]. More recently, cutaneous laser surgery has also been combined with highly effective delivery of pharmaceutical agents as an example of pharmacosurgery, to good effect [8].

However, cutaneous laser surgery is often underutilised due to the perceived concerns about the sustainability of a new service with relatively high startup cost. Herein, we present a 22 year cost-benefit critical analyis from an established UK cutaneous laser service, in terms of fiscal viability, service sustainability, direct and indirect effects on the health service and economy.

1.1. *Aim*

To explore the cost-benefit analysis of cutaneous laser surgery in the management of secondary burn surgery, through 22 year trend analysis from a large burn centre.

1.2. *Null hypothesis (H_o^1)*

That cutaneous laser surgery has no bearing on the cost-benefit analysis of cutaneous surgical disease, using seondary burn reconstruction as an example.

2. Method

This study utilised an evidence-based approach followed by an in-depth analysis of burn wounds at a large tertiary referral centre within the United Kingdom. Primary literature published in the last 5 years, in English, Italian, French, or Arabic in peer-reviewed journals was included in this study.

Primary literature was analysed for content relevance (title and abstract). The retrieved literature was then forward and back-referenced for secondary citations using Web of Knowledge™ database search. Content analysis for quality was based on the Centre for Evidence Based Medicine (Oxford)'s Hierarchy of Evidence [9]. The following databases were searched: pubmed, embase, Ovid™, Ovid SP™, Scopus™, and Web of Knowledge™. The Boolean search string "Laser AND burn AND cost" was used.

A retrospective analysis of service improvement data was performed, on patients requiring secondary burn reconstruction (traditional surgery and cutaneous laser surgery) at the Welsh Centre for Burns and Plastic surgey from 1996 to 2018. The amount of patients per year was plotted for comparison. Gross costings from the same unit were estimated from previously published local evidence relate to the 2005–2006 financial year.

3. Results and discussion

3.1. *Evidence-based analysis*

Sixty six studies fulfilled the inclusion criteria, and underwent relevance-screening for content, of which 8 studies were included (Fig. 1).

3.1.1. *Fiscal viability and sustainability*

Madni et al. [10] used a retrospective unmatched case-control analysis, comparing burn resurfacing using Erbium-YAG 2940 nm fractional resurfacing of burn scars over one year (n = 628) and compared these to historical controls performed using traditional surgery (n = 428), in order to explore the impact on the flow and productivity of a mature burns operating theatre.

Interestingly, theatre time was divided into induction, prep, procedure, transport out, and room turnover. The authors appropriately used similar cost codings, and student's t-test to compare the cohorts. Madni et al. used a single centre, single operating room setting which served to reduce potential confounding factors in their analyses. Their findings included a statistically significant increase in the cases performed per day, with a shorter per-case turnaround for all component times. Given that the authors cite a significant number of patients with complex airways, and given that the billing codes used reflect a substantial underestimation of the extent of the burn surface areas performed it is likely that this study substantially underestimates the extent of the procedure and the turnaround that may be potentially achieved.

Hultmann et al. [11], performed a retrospective, operational, and financial analysis of all burn patients who underwent laser treatment of hypertrophic burn scars over 4 financial years. Their results showed that a sustainable enterprise at US financial rates can be achieved when the provider has an economy of scale at their disposition, even when the steep costs associated with starting and operating a laser practice in a hospital setting are taken into account. Although this well-conducted study used evidence-based break-even formulas [12] to arrive at a break-even caseload of 10 cases per day, an indepth analysis of the costings does suggest that the costs in this study were performed using a conservative estimate. In this study, capital equipment costs were cited as per-day leasing cost ($1250 per 8 h day) whereas with most European national health service setups, outright purchase of capital equipment at the outset is commoner and may result in long term cost saving. Hiltmann et al., use more realistic code categorisations based on surface area (<10, 10–50 and >50 cm^2).

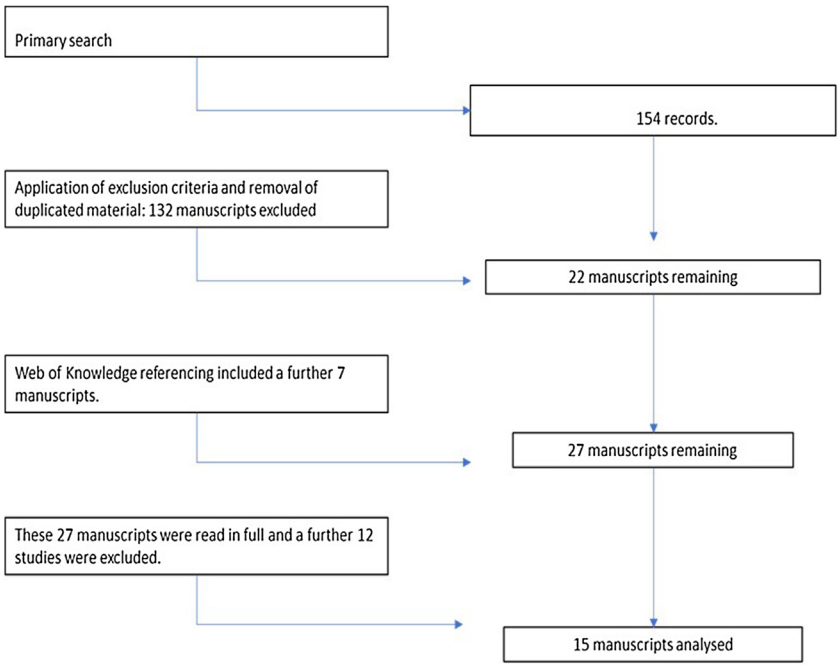

Fig. 1 – Flow diagram illustrating the process of literature selection. Primary literature retreivable with the Boolean search string "Laser AND burn AND cost", on published Pubmed, Embase, Ovid™, Ovid SP™, Scopus™ was retrieved. In the second phase, delimiting exclusion criteria (last 5 years, in English, Italian, French, or Arabic in peer-reviewed journals) and de-duplication were applied. In the third phase, primary literature was back-referenced and forward-referenced manually and through Web of Knowledge™. In the fourth phase, the 26 remainind records were reviewed (abstract and then body of text) for relevance by two blinded reviewers independently. Eight manuscripts were therefore selected. Literature search performed on 02.02.2019.

Appropriate procedural coding is critical to the financial viability of a laser service and correct procedural coding is critical to its survival [10,13]. Hiltmann et al. used CPT codes 17106, 17107, and 17108 (laser destruction of cutaneous vascular proliferative lesion) rather than a specific code. Further, both studies remarked on the majority of patients suffering from challenging airways, driving up the operational costs. Given this critical appraisal, both Madni et al. [10] and Hultmann et al. [13] may have taken a conservative approach, and while this suggests a rigorous methodology, it is also likely to have underestimated the cost benefit of these procedures. Availability of appropriate codes, albeit an administrative issue, is a major hurdle to uptake of cutaneous laser use in the United Kingdom, and a matter deserving urgent attention.

In agreement to the above two studies, a later systematic review on c. 800 patients by Hulltman et al. [14] reports that a laser service for hypertrophic burn scars has the potential to "dramatically reduce the cost of care", making it attractive to stakeholders, patients, providers and insurers. This rigorously conducted systematic review extensively reported inclusion-exclusion, primary study atrition and critical analysis. Due to the heterogeneity of primary data, like-studies were pooled before a narrative conclusion was formulated. This interesting approach allowed summation of outomes from heterogenous methodologies on a premise of "best available evidence" in this level 2 study. Interestingly, this study provides evidence of the substantial cost-saving that may be achieved with this modality, in terms of substituting traditional procedures which may be not only inherently more costly, but also entail significantly more resource consumption such as intensive therapy, and in-hospital stays, and successful weaning off complex pharmacological regimens such as those advocated for severe pruritis, debilitating paresthesias, and chronic pain. Laser treatment of hypertrophic burn scars almost always decreases pharmacologic therapy and allows some patients to discontinue many or all of their medications, such as narcotics, anxiolytics, antihistamines, and antidepressants. Less frequent clinical follow up has a positive domino-effect on health service resources, rehabilitation efforts, and active contribution to the economy through earlier return to productive employment [15].

Miletta et al. provide an experimential overview of their use of laser treatment for miltary hypertrophic scars and relate that in their extensive military practice, laser surgery is a cost-effective and successful method for management of these conditions. This study is useful in producing a personal flavour of extensive experience, however, given its narrative nature, may only be classified as level 5 evidence [16].

3.2. *Direct healthcare cost considerations*

A common trend in the above studies was to emphasise the viability of a well-run and maintained laser service [11,13,14,17]. However, an important point which is often missed in these considerations is the implications of cost-reductions arising from head to head comparison to traditional surgery to cutaneous laser surgery in terms of direct resource utilisation and reduction of complications. We

therefore analysed the trends in resource utilisation in a large tertiary hospital with more than 22 year history of offering laser services to burn patients for secondary burn surgery. The trend illustrated in Fig. 1 reports an inverse relationship of the throughput of traditional secondary burn surgery, with the throughput of the laser service.

However, a more in-depth analysis of the relative throughputs over a 22 year period shows that the relationship is not directly inverse. A small increase in the laser patient throughput resulted in a more substantial decrease in the secondary burn surgery performed at the same centre. The results over the last 10-year period analysed are reported in Figs. 2 and 3.

Institutional cost associated with burns admissions is in excess of £7 million per year [18]. The point prevalence at two time points where like-for like data exsits (2005–2006 versus 2015–2016), Fig. 2 resulted in a 47.3% reduction in secondary burn surgery. No major shift was reported in the interim period with regard to the management of secondary burn surgery except the exponential uptake of laser therapy in the interim period (Fig. 2). Halving of secondary burn surgery is substantially more than can be suggested simply by the epidemiological trend for decreasing burn injury in the UK. In this simplified model, the introduction and uptake of laser service within the remit of secondary burn reconstruction would result in a substantial operational cost saving. In keeping with published evidence [10], a cutaneous laser surgery service therefore significantly contributes to an effective and sustainable healthcare delivery model. This may be an important consideration for healthcare systems (including the UK NHS) facing significant cost-pressures (Fig. 3).

3.3. *Indirect healthcare cost considerations*

Complication rates following laser surgery are rarer and milder than traditional surgery. The cost of surgical site infection is estimated to extend length of stay by 9.7 days and increase cost

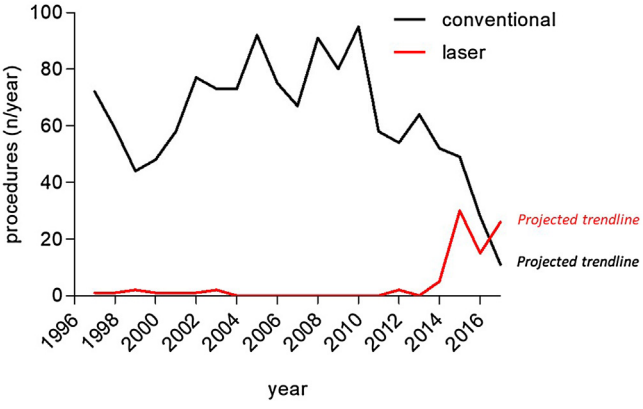

Fig. 2 – Effect of the laser service on burn contracture surgery. A significant decrease in the amount of major burn scar release procedures was concurrent with a substantially more modest increase in the amount of laser procedure performed within the same organisation. Increasing the range of indications will result in multiplied cost-savings. Source: ABM Quality Improvement and Departmental Audit Data. 1996–2017.

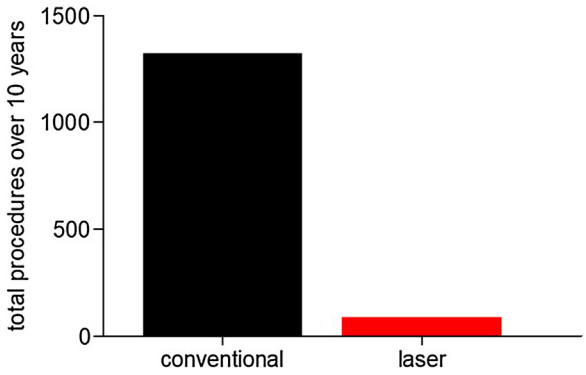

Fig. 3 – Effect of the laser service on burn contracture surgery. A moderate increase of laser procedures occurred at the same time as a substantial and sustained reduction in secondary burn reconstruction procedures per year.

by $20,842 per admission. infection is a major cause of morbidity mortality and cost of care [3,19–21]. In contrast, bacterial infection is exceedingly rare (<1%) in wounds treated with laser surgery [22]. A cutaneous laser service therefore presents an opportunity to release value from the cost of dealing with surgical complications, by reducing the inicidence of the latter.

Most patients can toleratre up to 30% total body surface area in one sitting, and most of these patients are ambulatory, being managed as day patients. All of these considerations point to further cost savings.

3.4. *Effect on the wider economy*

It is well-established that burn injury represents a significant economic cost. Within the Netherlands, mean total costs of burn care in the first 3 months post injury were estimated at €26,540 dependant on age, aetiology and TBSA [23]. In the US, the lifetime global cost of injury totals $406 billion, including $80 billion in medical costs and $326 billion in lost productivity [24]. The incidence of burn injury in 2004 was estimated to be 1.1 per 100,000 population, or an incidence rate of 0.19 per 100,000 [1] although it is well-established that burn injury patients consume substantially more healthcare resource per patient [25]. The significant improvements that can be achieved by laser management in burn reconstruction are well-accepted in the literature and extensively discussed elsewhere [8,26–28]. Considering the staggering cost of £40.6 billion caused by burn injury, the potential savings that can be achieved by even a modest cost-benefit improvement may translate into substantial savings for the State.

One important difference between Corso et al. [29] and the original Rice study [30] is the exclusion of quality of life costs or a non-monetised quality of life burden measure at the behest of the US Centre for Disease Control (CDC). Quality of life costs place a dollar value on the pain, suffering, and lost functional capacity experienced due to death and injury. Economic theory shows that some measure of quality of life burden should be included in the costs in order to use them in cost-benefit or cost-effectiveness analyses of the return on

investment of prevention. It is well-established that laser therapy leads to a substantial improvement in the quality of life through reduction of tightness, pruritus, reduced reliance on complex pharmacological regimens and follow-up. As the amount of lives saved by advances in emergency care, critical care medicine and acute burn surgery increases, it is likely that these benefits of laser, will be more palpably felt, multiplied by a lifetime.

3.5. *Limitations of the study and direction of future research*

To our knowledge, this is the first study to explore the impact of a laser service on secondary burn reconstruction over a twenty-year period. Inherent in this study are assumptions such as the continuously changing cost of healthcare services, and their organisations in different countries. In order to keep such confounding factors to a minimum, cost multiplications were always kept at the more conservative estimate. As an example, when comparing potential savings from 2005–2006 to 2015–2016, the multiplication was performed at 2005/6 costings, although incontestably, health care costs in the UK have increased over the next 10 years. Similarly, not all lasers are created equal, and this is also applicable to cost. This study assumes that cost considerations are broadly similar between different laser systems. Whilst this assumption might satisfy such an early exploratory report, there is clearly a difference in what can be achieved with ablative and non-ablative surgery, and clearly also a cost difference providing an avenue of investigation for future studies.

The conservative estimate presented by this study also presents scope for future research, with respect to the potential cost savings achieved from reduction in complications. It is well-established, for example, that the rate of postoperative infection following laser surgery is minimal, compared to ordinary surgery, and this has not yet been quantified. It is also important to caution that all these studies consistently reported outcomes from clinical surgeons with considerable expertise in the area, and who can tailor treatment to individual patient considerations on a daily basis, and deal with the complications.

Finally, although payment by results (PBR) has not been uniformly adopted within the United Kingdom, it is of particular concern that the extent and complexity of cutaneous laser surgery procedures is not yet formally captured in the latest OPCS codes within use in the United Kingdom [31]. We present this as a lacuna in central clinical governance that needs to be addressed as a matter of urgent concern.

4. Conclusion

This study reports that economic viability for laser surgery services for secondary burn reconstruction is supported by the evidence: level 2 (one systematic review) level 4 evidence (2 studies) and level 5 evidence (expert reports). Evidence from our own institution shows considerable cost savings sustained over a 22 year period in a super-regional UK burns facility. Analysis of the potential dollar-effect of these advantages to the general population supports state investment in expertise and capital equipment as a medium to long term cost saving strategy, which may also aid re-integrating patients into the workforce making a meaningful contribution to the economy.

Declarations

1 All authors have made substantial contributions to the manuscript.
2 The manuscript, including related data, figures and tables has not been previously published and that the manuscript is not under consideration elsewhere.
3 All authors declare that there are no conflicts of interest whatsoever.

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