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Neuroenhancement of future surgeons – Opinions from students, surgeons and patients

Dear Editor,

In recent years, there has been a substantial drive towards adoption of technological innovation in surgical training and practice, with The Royal College of Surgeons setting up "The Commission on the Future of Surgery" [1] to identify novel technologies likely to change care. It recognises innovations in surgical training and, in this regard, a number of research groups are exploring the role of neuroenhancement [2–6].

Emerging evidence suggests that transcranial direct-current stimulation (tDCS) improves laparoscopic skills and neurosurgical performance [2–5]. Similarly, performance scores on complex surgical bimanual tasks improve with tDCS when compared to sham [6]. Although these observations are encouraging, a number of important questions will resonate amongst both patients and surgeons surrounding safety, acceptability and the ethical concerns [7]. The scientific community has debated these issues and a survey of 265 researchers highlighted the methodological, safety and ethical challenges associated with tDCS [8]. Given the increasing pace of tDCS application to surgical skills, these issues should also be explored in a clinical context.

Here, we report opinions of medical personnel and patients regarding the implementation of tDCS in surgical practice. We conducted a qualitative survey gathering views on aspects of acceptability, safety and ethical implications of using tDCS in surgical practice. This included the views of medical students as they were considered to be potential future recipients of tDCS interventions.

Two surveys were created and scrutinised independently by a surgical focus group and a patient focus group respectively. Where appropriate, responses were compared between the two groups using the Mann-Whitney *U* test. Ethical approval (19/NS/0022) was obtained for distribution, and the survey was advertised and distributed to clinicians over the Internet using a variety of social media websites and via professional bodies including the Royal College of Surgeons Bulletin. Patients were approached whilst attending surgical outpatient appointments and completed either a paper version or an online version of the questionnaire. The sample sizes were based on prior surveys of patients and surgeons regarding novel technology and ergonomics in surgery [9,10].

In total, 191 patients [modal age range = 46–60 years (34%)] and a further 168 medical personnel [modal age range = 26–40 years (61%)] were surveyed. Respondents' survey opinions are summarised in Table 1. Briefly, assuming that tDCS was demonstrated to improve surgical performance, 80% of patients agreed or strongly agreed for it to be used by their surgeon. Both patients (86%) and medical personnel (80%) supported use of tDCS in surgical training, which was significantly stronger amongst patients [median Likert response: 5 (strongly agree) vs. 4 (agree), P = .002]. Both patients and medical personnel expressed support for NHS funding to be provided for tDCS (75% vs. 77%), and for research into its benefits in other medical areas (81% vs. 91%). In terms of safety, the most important evidence required for medical personnel was side-effect data from trials, with 98% advocating this information. Mechanistic understanding (82%) and endorsement from a governing body (75%) were also deemed important, with less emphasis placed on the use of tDCS by fellow peers (56%).

When asked if it is ok to improve a surgeon's ability with tDCS along with traditional training methods, 77% of patients agreed or strongly agreed. Similarly, 74% of medical personnel disagreed or strongly disagreed that this approach was "immoral". When asked more specifically if tDCS would provide an "unfair advantage" over other surgeons, responses were indifferent (neither agree nor disagree), but comparable between the two groups. The need to make tDCS mandatory if it was beneficial was opposed by both groups, but more so by medical personnel (60%) than patients (47%) (P = .036). Finally, overall, patients (76%) and medical personnel (73%) supported tDCS being regulated by a governing body rather than allowing individuals to determine use.

These research findings suggest an acceptance of neurostimulation by patients and medical personnel, provided efficacy and safety profiles were established. At first glance, the overall agreement of using tDCS in this setting is possibly expected as one would assume that implementation of technology that works well and is safe would be widely accepted. However, in the field of surgery it is highly unusual to adopt technology which directly influences the surgeon, rather than a tool which is used by the surgeon e.g. robotics. Furthermore, the passage of electrical current through the brain whilst conducting surgery or during training would naturally appear incongruous to clinicians unfamiliar with neurostimulation. Despite these characteristics, high level of support was present amongst medical personnel, and even more so amongst patients.

Medical personnel expressed a need to understand the underlying mechanistic effects before implementation and for safety data. Presently, tDCS is considered safe, however, long-term effects have not yet been established and further work is required to ascertain more subtle safety outcomes of repeated tDCS exposure. There continues to be ongoing developments to understand the neurophysiological mechanisms underlying tDCS. Furthermore, despite overall acceptance, there was clear opposition from both groups to making tDCS mandatory even if it was shown to be beneficial. We agree that enforcing neuromodulation in surgeons would be unethical,

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Table 1
Full reporting of responses.

	Patients						Clinical					P value
	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	Don't Know/No Response	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree	
Acceptability of tDCS												
If tDCS was shown to improve surgical performance, it would be most beneficial in surgeons who are:												
Below Average	43%	25%	6%	8%	3%	15%	25%	42%	20%	11%	2%	<0.001
Average	45%	29%	7%	3%	2%	14%	16%	54%	21%	7%	1%	<0.001
Above average	51%	27%	5%	4%	1%	13%	10%	45%	32%	11%	2%	<0.001
Junior Surgeons	–	–	–	–	–	–	20%	49%	18%	11%	2%	–
Senior Surgeons	–	–	–	–	–	–	11%	37%	30%	19%	2%	–
If tDCS improved a surgeon's performance, I would be happy:												
for it to be used by my surgeon	46%	34%	8%	4%	2%	7%	–	–	–	–	–	
for it to help with the training of surgeons	55%	31%	4%	1%	1%	8%	47%	33%	8%	5%	5%	.002
for the NHS to consider funding it	47%	28%	11%	3%	1%	10%	49%	28%	17%	2%	4%	.301
for use of research funding to look for benefits in other areas of medicine	57%	24%	6%	2%	0%	11%	59%	32%	5%	2%	2%	.383
to use it in routine operations	–	–	–	–	–	–	45%	30%	12%	11%	2%	–
to use it in complex operations	–	–	–	–	–	–	48%	32%	8%	8%	2%	–
to use it in unfamiliar operations	–	–	–	–	–	–	42%	21%	18%	13%	5%	–
Safety of tDCS												
If tDCS was demonstrated to be safe, I would be happy (for my surgeon) to use it:												
Before my operation	49%	26%	5%	1%	1%	18%	17%	53%	17%	3%	10%	<0.001
During my operation	41%	24%	8%	4%	2%	21%	14%	45%	20%	12%	10%	<0.001
Only as part of their training	46%	18%	6%	3%	2%	25%	22%	50%	13%	5%	9%	<0.001
What information is important for you to believe tDCS is safe:												
Side-effect data from trials	–	–	–	–	–	–	74%	24%	1%	0%	0%	–
Complete understanding of the mechanism	–	–	–	–	–	–	49%	33%	12%	5%	1%	–
Use by the majority of colleagues and seniors	–	–	–	–	–	–	22%	34%	30%	12%	2%	–
Endorsement by a governing body e.g. NICE	–	–	–	–	–	–	36%	39%	15%	8%	1%	–
Ethics of tDCS												
Use of tDCS should be regulated by a governing body, rather than allowing individuals to decide when to use it.	49%	27%	9%	7%	1%	7%	30%	43%	16%	9%	2%	<0.001
If shown to be beneficial, tDCS should be a requirement for all surgeons to use it.	17%	16%	14%	26%	21%	6%	2%	12%	26%	43%	17%	.036
A surgeon using tDCS would give him or her an unfair advantage over other surgeons	4%	19%	27%	20%	9%	22%	5%	13%	36%	39%	7%	.091
It is ok to improve a surgeon's ability in this way along with traditional training methods	37%	40%	13%	1%	1%	8%	–	–	–	–	–	–
Improving ability in this way is immoral	–	–	–	–	–	–	2%	4%	20%	48%	26%	–

even if there was potential to improve performance, and surgeons should retain autonomy over whether they choose to use it. Similarly, for those willing to use tDCS, the majority of both groups deemed it important for a regulatory body to oversee its use. This is a sentiment that is echoed amongst researchers in the field who strongly felt that tDCS should not be made available to the public due to a lack of mechanistic understanding and fear of safety concerns and misuse [8].

Limitations of this study include reporter bias due to tDCS naivety and an inability to report on response uptake or how many declined to participate, hence non-response bias. However, this study suggests that tDCS would generally be accepted by patients, medical students and surgeons, provided it was demonstrated to be safe, reliable and effective. Further work is required to verify safety profiles alongside potential benefits in training and the clinical setting, prior to it being incorporated in healthcare.

Declaration of competing interest/disclosures

The authors have no related conflicts of interest to declare.

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