

Dear reviewers,

Thank you for giving us the opportunity to submit a revision and considering our manuscript 63046, entitled "5G mobile communication applications for surgery" for publication in *Artificial Intelligence in Gastrointestinal Endoscopy*. We would also like to thank the reviewers for their distinguished work and effort to help us providing an improved manuscript.

The following changes have been made according to your suggestions (changes highlighted in red color text in the new version of the manuscript and our answers in the following comments).

Reviewer #1:

We want to thank reviewer #1 for the distinguish work on our manuscript. Please find your questions and remarks answered in the following.

1. The authors summarize the requirements for network in remote surgery, but do not illustrate how 5G can meet these requirements. In other words, please clarify the key 5G technologies that can meet the data rate and delay requirements.

Please find the clarification in the chapter *Benefits and applications of 5G in surgery*:

"As outlined before, key requirements for remote surgery are a high bandwidth with a fast data transfer without delays. 5G mobile networks meets these requirements. With a data rate in the gigabit range, previous stated necessary bandwidths of 7 Mbit/s (11) are easily met. The same applies for the necessary latency for remote surgery which has been defined to be below 300 ms. (6, 9, 30-32) 5G offers a 1 ms latency and therefore represents a huge improvement for this crucial aspect in surgery."

2. I am still confused about what technical problems we may face when applying 5G into remote surgery and how to solve these problems.

Thank you for this hint. We agree and added following section:

"Although the 5G technology already exists the biggest technical issue is simply its pending implementation in daily life. In Germany, the expansion of the 5G network was subjected to a politically regulated and costly tender. Now, four providers started to offer 5G in Germany, but it is far from being universally available. (56) Due to its high frequencies more antennas are needed to create a stable 5G network. Therefore, more radio masts need to be constructed in urban as well as in natural areas. However, this might interfere with citizen movement and nature conservation organization interests."

3. In the comparison between 4G and 5G, only the benefits of 5G are listed in the article, but the problems faced by 5G are not listed.

We agree and therefore revised the section comparing LTE with 5G.

"However, the high frequencies of 5G explain two disadvantages compared to LTE. With higher frequencies, wavelengths become smaller and therefore penetrate objects worse. Consequently, LTE is less susceptible for blockage by objects in a room than 5G. (44, 45) Second, 60 times less distance can be overcome by the high bands of 5G. (44) "

4. The last sentence in Paragraph I, Section I is too complex to understand. It is suggested to adjust it to shorter sentences.

We agree and changed this paragraph to the following:

“The internet presents a base to solve existing problems in our health care system: First, medicine to have become impersonal instead of individual. Secondly, healthcare to be provider-centered instead of invalid-centered. Finally, medical treatment to be uneven available instead of accessible to any ethnicity, income, and geographic location.”

5. I wonder if there are any other applications of 5G in surgery except for the remote surgery. For example, you mentioned the IoT network, could you please provide more details?

Thank you for this hint. Besides the 5G application for remote surgery, we also mentioned the improvement for high quality video transmission and tactile sensation in robotic surgery. Furthermore, we argued the combination with technologies like Virtual Reality, Augmented Reality and AI. Please find these examples in Section 3, Paragraph 5 & 6. To explain the IoT network in greater detail, we added following sentence:

“An already existing IoT-technology in the medical sector is to monitor blood sugar levels of patients with diabetes via integrated sensing device and smartphones. This technology could be extended meaning that other human measurable parameters could directly be transmitted from an integrated sensing device to a monitor wirelessly and remotely.”

6. The article mentioned that all researchers believe that 5G can play a great role in remote areas, it also mentioned that the construction of 5G requires a large amount of financial expenditure. Could you make a comparison with the resources spent in the construction of cable network?

We agree that a comparison regarding the financial expenditures illustrates the discrepancy between both mentioned aspects. We added the following sentence:

“It is estimated that the network expansion of 5G in a country with the size and economic status like Germany costs tens of billion Euros.”

7. It is stated in the literature that few studies have proved the effectiveness and feasibility of 5G in surgery. Could you please briefly analyze why this is the case?

We changed the sentence to the following:

“ [...] most likely due to the lack of a standard 5G network and the expense to establish a technical setup.”

8. In the remote surgery scenario, how many parts does the delay consist of? What is the value of the delay for each part? To reduce the delay of each part, please elaborate on the potential solutions.

We explained and discussed the remote study case with its parts causing the delay in greater delay. Please find the revision in the study description part as well as in the discussion part.

“The parts of the total latency consisted of the mean round-trip delay, the servo period of the surgical robot (< 1 ms), the mechanical response delay of the robot (40 ms), the endoscope imaging and image processing delay (50 ms), and the video codec delay (60 ms). Mentioned times were the same in both network setups but the mean round-trip delay which was 114 ms (108 – 124 ms) for 5G and 56 ms (54 – 60 ms) for the wired network setup.”

“When looking closer at the parts causing the latency it is noticeable that the 5G and wired connection setup only differ in the time of the mean round trip delay. A detailed explanation for the longer mean round trip delay of the 5G network is not provided by the authors. A lack of enough 5G antennas between the patient and surgeon side might be an explanation.”

9. To achieve low-latency and high-reliability transmission, as far as the current solutions are concerned, please discuss in details what are the shortcomings in this submission.

We do not understand the question. Shortcomings of the technology were added under (3)

Reviewer #2

We also want to thank reviewer #2 for the revision of our manuscript. Please find your questions and remarks answered in the following.

This is descriptive study focusing on the 5G in surgery The issue is interesting since knowing the real impact of the 5G in surgery could improve surgical behavior in the real life. However, there are some major issues that should be clarified from the authors as, this is not a systematic review neither a meta analysis. This could be define better as a Letter to the editor an invitation to the expert.

We did not intend to provide a systematic review or meta analysis on this issue as the amount of the current literature does not allow it due to the novelty of the 5G technology. We also did not state this was such a review or analysis. Our intention was to provide a literature review focusing on 5G but also to understand the history of the internet in surgery and future chances/challenges. We followed the example for a literature review provided on the Baishideng Publishing Group homepage.

1 In the last part of the introduction, there are some results data, such as the number of paper included, etc etc...

Thank you for this hint. We adjusted this part by inserting “Methods”.

2 The title should better define the type of the paper

Thank you for this hint. Please find the title revised.

5G mobile communication applications for surgery - An overview of the latest literature

3 Some tables might help to better understand the type of devices used.

Please find a table attached at the end of the manuscript listing the devices used in the distinct studies.

4 Some comments about Ethical problems that might entail performing a surgery from another country.

We appreciate this aspect and included some comments on this issue.

“From an ethical point of view, the topic of dehumanizing can become a greater issue when remote surgery becomes reality with 5G. The surgeon will not physically interact with his patient and therefore more likely comprehend his patient just as a data set. (15) The sense of responsibility can be lost, and the criticized mechanization of medicine could be enhanced instead of resolved by 5G.”

We want to thank the editor and all reviewers for their distinguished work and effort to help us providing an improved manuscript. We appreciate our manuscript to be considered for publication.

Best regards,
H. Fuchs, MD