


RESEARCH ARTICLE

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Effectivity of near-peer teaching in training of basic surgical skills – a randomized controlled trial

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Abstract

Background: Near-peer teaching (NPT) is a special way of teaching where the tutor is one or more academic years ahead of the person being tutored. The literature agrees on the benefits of the method, but there are only a few publications examining its effectiveness using objective methods. The aim of our study was to examine the effectiveness of NPT in the training of basic surgical skills.

Methods: We included 60 volunteer students who participated in a 20 × 45 min long surgical skills course. Based on the results of a pre-course test, we randomly divided the students into six equal groups. All groups completed the same curriculum, with three groups being assisted by a NPT tutor. After the course, they completed the same test as at the beginning. The exams were recorded on anonymized videos and were blindly evaluated. The students' satisfaction was monitored using a self-administered online anonymous questionnaire. Statistical analysis was performed using the Mann-Whitney and Wilcoxon tests.

Results: Overall, student performance improved with completion of the course (from 119.86 to 153.55 points, $p < 0.01$). In groups where a NPT tutor assisted, students achieved a significantly better score (37.20 vs. 30.18 points improvement, $p = 0.036$). The difference was prominent in surgical knotting tasks (14.73 vs. 9.30 points improvement, $p < 0.01$). In cases of suturing (15.90 vs. 15.46 points) and laparoscopy (7.00 vs. 4.98 points), the presence of the NPT tutor did not significantly affect development. Based on student feedback, although students positively assessed the presence of NPT, it did not significantly improve students' overall satisfaction since it was already 4.82 on a scale of 5 in the control group.

Conclusions: Overall, involving a NPT tutor had a positive impact on student development. An outstanding difference was observed in connection with knotting techniques.

Keywords: Near-peer teaching, Surgical education, RCT, Basic surgical skills, Suturing

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Background

Near-peer teaching (NPT) is gaining popularity as an effective teaching method in medicine, especially in anatomy and basic sciences. Furthermore, its benefits have already been documented in detail in surgery, paediatrics, pathology, orthopaedics and family medicine [1–10].

Peer education after Topping can be defined as individuals from a similar social group who, as non-professional educators, help each other in learning and learn by teaching themselves [11]. Although there is no uniformly accepted definition of NPT, the already existing descriptions basically agree that it is a form of peer education in which a student in the teaching role participates in the same training but is at least one academic year ahead in his or her studies than the student in the student role [12, 13].

A widely accepted principle of the method is to exploit the benefits of cognitive and social congruence. Cognitive congruence (i.e., similar prior knowledge and study experiences) allows the use of language that is certain to be understood by the learner, as well as the appropriate choice of the logic and conceptual framework of the explanation, which helps the learner to understand. Social congruence (i.e., a similar role) allows for the creation of a calm and easy educational environment [13–15].

Although several publications have reported positive changes (such as the development of confidence or understanding) using the NPT method, these are mostly based on subjective impressions and opinions. Only a few studies were found that examined the effectiveness of NPT using objective and prospective techniques [1, 2, 16–18].

We have found just one publication by Preece et al. examining the effectiveness of NPT in teaching surgical skills. They found the use of peer-assisted learning as an effective, cheap and sustainable way to teach suturing skills, although they did not involve control group in their study [19].

Methods

The aim of our research was to objectively investigate the effectiveness of NPT related to basic surgical skills.

Main hypothesis

Involvement of NPT in surgical education improves the exam results of the students participating in the course.

Secondary hypothesis

Involvement of NPT in education improves the satisfaction of students participating in the course.

Study design

Single-blinded, prospective, parallel group, randomized controlled trial.

Population of the study

Our sample size calculation was based on the test results of previous years. The study sample estimate envisaged the involvement of 58 students, estimating a 3-point difference between the study and control groups ($\alpha = 0.05$, $\beta = 0.1$). Based on these, we included 60 volunteer students (30 women and 30 men, with a mean age of 22.6 ± 2.2 years) in the study. The criteria for student participation was the successful completion of the 'Basics of Surgery' course for the third-year pre-clinical curriculum of our university; however, the student should not complete the surgery summer practice after the fourth-year. So, participants were third- and fourth-year medical students.

Three volunteer peer educators were also involved in the research. The NPT tutors were sixth-year medical students who had successfully completed the surgical subjects included in our university's compulsory curriculum, completed the simulation training centre's own NPT preparation course (including an exam with test-training), and had a minimum of 1 year of NPT experience (NPT tutors).

The teaching staff consisted of three practicing clinical physicians working in the manual medical profession with at least 3 years of teaching experience (instructors).

Video recordings were evaluated with the involvement of three senior instructors who had a minimum of 10 years of teaching experience and 5 years of examination experience as clinical specialists working in the manual profession (senior instructors).

The study was approved by the Institutional Ethical Review Board (7719-PTE 2019).

Protocol including procedural details

Prior to the course, all students underwent a preliminary aptitude test. In doing so, we assessed their existing skills in surgical knotting techniques, basic suture techniques, and basic laparoscopic skills. Knotting and suturing exercises were recorded on video, which was evaluated anonymously by the three senior instructors. We took into account the average of the scores given by the instructors. Laparoscopic skills were scored based on an evaluation sheet issued by the simulator.

1. Based on the scores obtained we divided the students into 4 groups (from poor to excellent performance). After this we have assigned a number between 1 and 6 randomly to the students within each group separately. Thereby six homogenous

group of 10 with almost equal initial scores were created.

2. An NPT tutor and instructor were assigned to the three groups by drawing lots (study group), and then an instructor was assigned to the remaining three groups by drawing lots (control group). So, each instructor had a group where a NPT tutor would help with their work and one where they would hold the lesson alone.
3. All groups took a 20 × 45 min course with the same timeline on different weeks, including:
 - a. Deepening the knowledge of the instruments and introduction of suture materials – 45 min
 - b. Two-handed (surgical) and one-handed (Viennese) knotting - 4 × 45 min
 - c. Simple knot stitch, instrumental (apodactyl and atraumatic) knot and Zagreb's knot – 2 × 45 min
 - d. Vertical mattress (Donati) and Allgöwer-Donati sutures - 2 × 45 min
 - e. Intracutaneous running sutures - 3 × 45 min
 - f. Laparoscopic basic (device knowledge and camera use) – 2 × 45 min
 - g. Laparoscopic skill development - 4 × 45 min
 - h. Free practice according to the student's preference – 2 × 45 minutes
4. The skills of the students were assessed on the day after the end of the course in the same way as before the course.
5. At the end of the course, students completed a self-administered online anonymous questionnaire that measured their opinion about the course and the application of the NPT on a Likert scale of 5.

Protocol of the evaluation

Surveys were conducted before and on the day after the course under the supervision of the instructors. Students completed the assignments independently, without assistance, which were videotaped so that the student's identity could not be identified (Fig. 1).

Videos were evaluated by senior instructors based on the Objective Structured Assessment of Technical Skill (OSATS) after they were settled and randomly ordered. To evaluate knotting, we used a slightly modified version of the criteria published by Shen et al. (Tables 1 and 2), and we developed our own criteria system to evaluate the sutures (Table 3) [20]. Prior to the course, we took test recordings with the help of the NPT tutors and instructors to check the usability of the scorecard, and the evaluators learned how to use the method. Training was continued until the senior instructors received an α value above 0.95 in intraclass correlation studies.

Tasks of exam

1. Two-handed knot in the tension tissue model, with the latex rubber band of knotting trainer (three pieces with the right hand and three pieces with the left hand) evaluation according to OSATS (Table 1)
2. One-handed knot in the torn fabric model, with the magnetic hook of knotting trainer (three pieces with the right hand and three pieces with the left hand) evaluation according to OSATS (Table 2)
3. Simple interrupted suture, with atraumatic suturing material and instrumental knot with suture pad (three pieces) evaluation according to OSATS (Table 3)
4. Vertical mattress (Donati) suture, with atraumatic suturing material and instrumental knot with suture pad (three pieces) evaluation according to OSATS (Table 3)
5. Intracutaneous running suture, with atraumatic suturing material and instrumental knot with suture pad (4 cm) evaluation according to OSATS (Table 3)
6. Performing a "Peg transfer-Level 1" task on a LapVR v4.0.399.46816 (CAE Healthcare, Sarasota, FL, USA) simulator (the better result of two attempts) evaluation based on the evaluation sheet

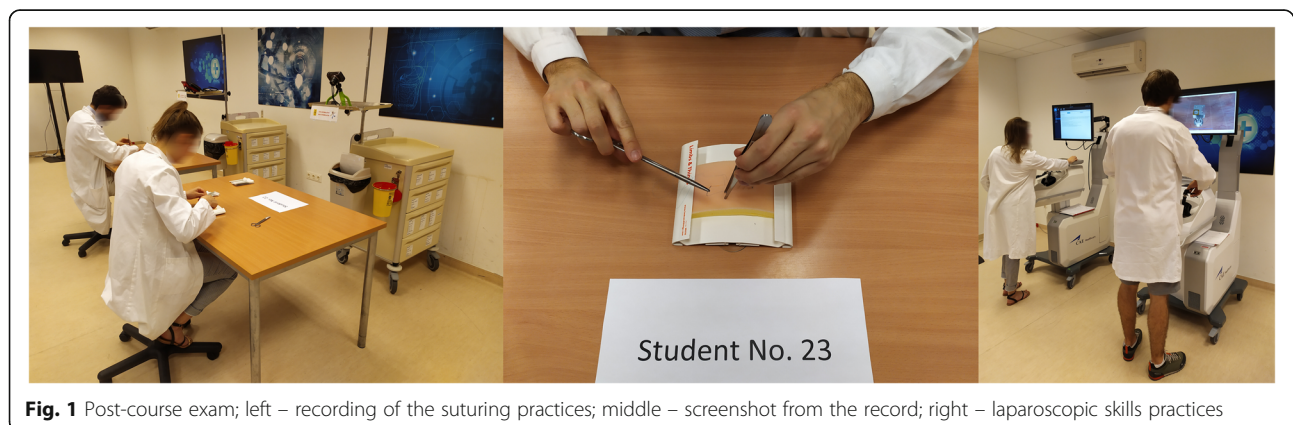


Fig. 1 Post-course exam; left – recording of the suturing practices; middle – screenshot from the record; right – laparoscopic skills practices

Table 1 Assessment of two-handed knot-tying techniques

	1 point	2 points	3 points
Tension of knot-tying cords during the method	Mostly loose	Mostly tight	Always tight
Motion	Many unnecessary moves	Less unnecessary movement	No unnecessary movement
Direction of the first knot	Wrong (knot failure)	Not ideal (knot failure)	Good
Direction of knots	Always the same	Partially alternating	Alternating
Positioning of the knot	Did not push down	Mostly pushed down	Always pushed down
Respect of tissue	The latex rubber band always moved in the direction of the hand (knotting material is too tight)	Unnecessary movements of trainer's latex rubber band	The latex rubber band did not move towards the hand
Stability of the knot	Loose loop, the edges of the rubber did not line up	The edges of the rubber just fit together	Good stability, the edges of the rubber fit together
Time	60 s<	45-60 s	< 45 s

issued by the tool. If all the conditions were met, then the time allotted for the task was scored (one-tenth of the total time required to complete the task was subtracted from 35).

Statistical analysis was performed using the Mann-Whitney U Test and Wilcoxon signed-rank tests (IBM SPSS v23, IBM Corp., Armonk, NY, USA). The RANDBETWEEN function of Microsoft Excel v14.0.6112.5000 (Microsoft Corp., Redmond, WA, USA) was used for randomization. $P < 0.05$ was considered significant.

Results

The results of the pre-course test in the control groups without the NPT tutor (the overall results of the students were 120.406 points) did not differ significantly from the study groups that included the NPT tutor (119.320 points, $p = 0.679$).

Taking into account the overall results of the students, a significant improvement was achieved in all areas during the completion of the course (average 33.690 point improvement, $p < 0.001$) (Table 4).

In the groups where the NPT tutor assisted the teaching, students achieved a significantly greater improvement (30.180 vs. 37.200 point improvement, $p = 0.036$); however, this difference was significant only for the tasks related to knotting (9.300 vs. 14.733 point improvement, $p = 0.003$). There were no significant differences in tasks related to suturing (15.900 vs. 15.497 point improvement) and laparoscopic basics (4.980 vs. 7.000 point improvement) (Tables 5 and 6).

Based on the feedback of students, although students positively assessed the presence of demonstrators (4.80 on a Likert scale of 5), this did not significantly affect their satisfaction (4.77 vs. 4.83, $p = 0.28$) (Table 7).

Discussion

In the course of our research, we assessed the effect of the technical application of NPT on the development and satisfaction of students using an objective method among homogenized groups.

Main hypothesis

We successfully proved our main hypothesis that the involvement of a peer educator in the teaching of basic

Table 2 Assessment of one-handed knot-tying techniques

	1 point	2 points	3 points
Tension of knot-tying cords during the method	Mostly loose	Mostly tight	Always tight
Motion	Many unnecessary moves	Less unnecessary movement	No unnecessary movement
Direction of the first knot	Wrong (knot failure)	Not ideal (knot failure)	Excellent
Direction of knots	Always the same	Partially alternating	Alternating
Positioning of the knot	Did not push down	Mostly pushed down	Always pushed down
Respect of tissue	The magnetic hook elevated	The magnetic hook elevated slightly	The magnetic hook did not elevate
Stability of the knot	Loose loop, fell off the hook	The knot slipped off the hook	Good stability, knot did not slip off the hook
Time	60 s<	45-60 s	< 45 s

Table 3 Score system used for assessment of sutures

	1	2	3
Hold the needle at 1/3	Not even once	Sometimes	Always
90 ° between the surface and the needle	Not even once	Sometimes	Always
Appropriate usage of forceps	Wrong	Intermediate	Excellent
Appropriate direction and technique of knotting	Wrong	Intermediate	Excellent
Appropriate tightness of the knot	Wrong	Intermediate	Excellent
Appropriate position the skin edges	Wrong	Intermediate	Excellent
Appropriate distance from the skin edge	Wrong	Intermediate	Excellent
Appropriate distance between sutures	Wrong	Intermediate	Excellent
Respect of tissue	Unnecessarily damaged the tissue	Handled the tissue carefully, but accidentally caused inadvertent damage	Did not damage the tissue
Time and motion	Did not finish within 4 min	Done in time, but a lot of unnecessary movements	Done in time, worked effectively
Maintenance of asepsis	Did not reach	Strived for it, but accidentally violated it	Reached
SUM			

surgical skills significantly improved the exam results of the students.

The course where also an NPT tutor attended the students' education showed significantly better results in the tasks related to knotting, while no differences were found between the study and control groups in the tasks related to suturing and basic laparoscopic techniques. This controversial result may be due to several reasons. The need for a high degree of personalized attention to the teaching of knotting can be one of them. By breaking it down into its elements and presenting professional hand movements individually, it is easier to learn the right technique. In suturing and laparoscopy, the appropriate technique and video assistance can also be effectively demonstrated for larger groups. At the

same time, the instructor can check the end result more easily in larger groups, and the self-checking processes are easier as well. Viewing the finished seam line or the feedback provided by the laparoscopy simulator, it easily reveals type errors without the instructor. Another reason can be, that the post-course exam result of the suture skills reached the 88,2% of the possible maximum points in the control group leaving only a few potential for more improvement in the study group. We also need to acknowledge that 6 sessions of 45 min of laparoscopy education is probably a too short amount of training time for such complex skills to see the effect of NPT.

Although we did not find any publication in the literature, we reviewed the ones that we could directly

Table 4 Aggregate results of students' surgical skills pre- and post-course

	Pre-course	Post-course	Improvement	Wilcoxon (p)	Z
Overall results	119.863	153.553	33.690*	< 0.001	-6.736
Knotting	27.767	39.783	12.017*	< 0.001	-6.740
Two-handed knotting	13.583	19.333	5.750*	< 0.001	-6.724
One-handed knotting	14.183	20.450	6.267*	< 0.001	-6.514
Sutures	72.533	88.217	15.683*	< 0.001	-6.618
Simple interrupted	24.067	29.467	5.400*	< 0.001	-6.205
Vertical mattress (Donati)	24.667	29.517	4.850*	< 0.001	-5.799
Intracutaneous running	23.800	29.233	5.433*	< 0.001	-6.342
Laparoscopic basics	19.563	25.553	5.990*	< 0.001	-6.283

The average points and the results of the Wilcoxon signed-rank test (*significant difference between pre- and post-course results)

Table 5 The results of the pre- and post-course tests of the control and study groups

	Pre-course				Post-course				Improvement			
	Control group		Study group		Control group		Study group		Control group		Study group	
	pt	%	pt	%	pt	%	pt	%	pt	%	pt	%
Overall results	120,41	68,0%	119,32	67,4%	150,59	85,1%	156,52	88,4%	30,18	17,1%	37,20	21,0%
Knotting	28,73	59,9%	26,80	55,8%	38,03	79,2%	41,53	86,5%	9,30	19,4%	14,73	30,7%
Two-handed knotting	13,73	57,2%	13,43	56,0%	18,33	76,4%	20,33	84,7%	4,60	19,2%	6,90	28,8%
One-handed knotting	15,00	62,5%	13,37	55,7%	19,70	82,1%	21,20	88,3%	4,70	19,6%	7,83	32,6%
Sutures	71,37	72,1%	73,70	74,4%	87,27	88,2%	89,17	90,1%	15,90	16,1%	15,47	15,6%
Simple interrupted	23,77	72,0%	24,37	73,8%	29,33	88,9%	29,60	89,7%	5,57	16,9%	5,23	15,9%
Vertical mattress	24,63	74,6%	24,70	74,8%	29,07	88,1%	29,97	90,8%	4,43	13,4%	5,27	16,0%
Intracutaneous running	22,97	69,6%	24,63	74,6%	28,87	87,5%	29,60	89,7%	5,90	17,9%	4,97	15,1%
Laparoscopic basics	20,31	67,7%	18,82	62,7%	25,29	84,3%	25,82	86,1%	4,98	16,6%	7,00	23,3%

pt Point, % Percentage of the possible maximum points

compare to our results. They are consistent with our general findings that the application of NPT could improve students' exam scores.

In the study by Preece et al., senior medical students delivered two suturing workshops to 35 students. They had significant improvement in the number of the completed number of sutures and inter-suture distance. All students found the workshop helpful and the teaching environment relaxed. Furthermore, 87% of the students reported that the workshop increased their interest in a surgical career [19].

In randomized controlled studies, Hudson and Tokin demonstrated that NPT tutors can be at least as effective in teaching history and physical examination skills as graduate doctors, as well as others in the field of resuscitation training, bladder catheterization and intravenous cannulation [16–18].

In basic science, Gallan et al. (biochemistry), Jackson et al. (physiology), and Sawyer et al. (first-year

curriculum) demonstrated the effectiveness of the use of additional NPT courses [21–23]. Alcamo et al. demonstrated the effectiveness of the USMLE Step 1 preparatory NPT course [24]. However, these studies are limited by the fact that NPT education was present as a complement, an additional learning opportunity.

In their retrospective study, Cate et al. compared the groups taught by NPT tutors and faculty for 36 courses (in the topic of circulation and metabolism) and found higher scores in 29 cases compared the groups taught by only NPT tutors [15]. The effectiveness of the method for teaching musculoskeletal competence has also been demonstrated with the involvement of orthopaedic residents [2].

In the reviewed literature, only Batchelder et al. did not find the application of the NPT method effective in terms of student exam scores, although they also reported that students in the programme felt more prepared and “more familiar with the

Table 6 The changes between the pre- and post-course tests of the control and study groups

	Control group	Study group	Difference	Mann-Whitney (p)	Z
Overall results	30.180	37.200	7.020*	0.036	-2.100
Knotting	9.300	14.733	5.433*	0.003	-2.949
Two-handed knotting	4.600	6.900	2.300*	0.011	-2.536
One-handed knotting	4.700	7.833	3.133*	0.004	-2.849
Sutures	15.900	15.467	-0.433	0.865	-0.170
Simple interrupted	5.567	5.233	-0.333	0.789	-0.267
Vertical mattress (Donati)	4.433	5.267	0.833	0.528	-0.631
Intracutaneous running	5.900	4.967	-0.933	0.422	-0.802
Laparoscopic basics	4.980	7.000	2.020	0.156	-1.420

The average points and results of the Mann-Whitney U test (*significant difference between the control and study groups)

Table 7 Results of students' feedback

	Control group	Standard deviation	Study group	Standard deviation	Mann-Whitney (p)	Z
1. Do you consider the material taught to be useful for your future profession?	4.90	0.31	4.80	0.41	0.28	-1.08
2. How do you judge the level of the course?	4.50	0.68	4.43	0.73	0.74	-0.33
3. Have you found the course interesting?	4.70	0.47	4.60	0.62	0.66	-0.44
4. Do you think the lessons were easy to understand?	4.87	0.35	4.87	0.35	1.00	0.00
5. Did you have enough time for practicing?	4.97	0.18	4.83	0.38	0.09	-1.71
6. Did the course leader/demonstrator pay enough attention to you?	4.83	0.75	4.83	0.38	0.26	-1.13
7. How do you feel and how much have your manual skills developed?	4.67	0.55	4.47	0.63	0.18	-1.33
8. All in all, how would you evaluate the course?	4.83	0.46	4.77	0.50	0.51	-0.66
9. Was the presence of the NPT tutor on the course useful?			4.70	0.53		
10. Could the NPT tutor help your progress?			4.67	0.55		
11. All in all, how would you judge the presence of the demonstrator?			4.8	0.41		

Average result, standard deviation and results of the Mann-Whitney U Test

style of exam questions" when there were NPT tutors [25].

Secondary hypothesis

Our results were insufficient to judge possible change in student's satisfaction since the overall satisfaction of the control group reached 4,83 on a scale of 5 leaving no room for more improvement. However, students, in line with the available international literature, found the application of the NPT technique useful and felt it helped their development [1, 3, 7].

Limitations

Based on our result it can not be declared that the reason of the significant improvement is the NPT as method, and not just the involving of an extra tutor ("workforce"), although exploring the reasons was not aim of this study.

The senior instructor who evaluated the admissions was aware that she was looking at taking a pre- or post-course exam, which could affect her evaluation. However, the main issue of the present study was not to assess the overall improvement achieved during the course, but to compare the study and control groups, for which the evaluation was completely blind.

The personality of the demonstrator and instructor may have influenced the result. Although in the case of the instructor, we tried to eliminate this by the fact that all instructors also participated in the training of one control and one study group. At the same time, we tried to further reduce this effect by forming six groups and involving several instructors and demonstrators.

Cross-examination may be a more ideal choice to answer this question. But due to the nature of the curriculum, we thought this would be very difficult to do.

Conclusions

We could confirm that the presence of a peer educator (NPT tutor) had a positive impact on student development.

Based on the results of our research, the application of the NPT technique can be a cost-effective and mutually beneficial way to increase the impact of basic surgical skills' training.

Abbreviations

NPT: Neer-peer teaching; OSATS: Objective Structured Assessment of Technical Skill; SUM: Summary; pt: Point

Acknowledgements

We are grateful to the staff of the Medical Simulation Education Centre, especially Péter Szücs, for their help with the exam recordings. We would like to state that the OSATS scores used in this study were already mentioned but not published in a recent paper of the research group. The study by Schlégl et al. was performed and published during the time of data processing and interpretation of this research [26].

Authors' contributions

P.Zs: helped building the study design, take part as NPT tutor, performed the statistical analyses, put together the final manuscript. K.D., V.P: take part as instructor, reviewed the manuscript. K.E., A.K: take part as NPT tutor, reviewed the manuscript. T.P, R.Sz, C.L: reviewed the study design, take part as senior instructor, reviewed the manuscript. F.Zs: reviewed the study design, verified the statistical analyses, designed the student's feedback study, reviewed the manuscript. S.Á.T: designed the study, take part as instructor, verified the statistical analyses, helped putting together the manuscript. All authors read and approved the final manuscript.

Funding

This work was supported by the Hungarian Government [grant numbers TUDFO/51757-1/2019-ITM, 2020-4.1.1-TKP2020 and NTP-NFTÖ-20-B-0137]. The founder granted the necessary consumables and labor cost for the study.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due data protection of the participants but are available from the corresponding author on reasonable request.

Declarations**Ethics approval and consent to participate**

The study was approved by the Institutional and Regional Ethical Review Board of University of Pécs (7719-PTE 2019). Written informed consent was obtained from study participants. All participant agreed to take part in the study, and approved to use their data for research purposes.

Consent for publication

Not applicable.

Competing interests

No benefits in any form have been received or will be received from a commercial party related, directly or indirectly. The authors declare that there are no potential conflicts of interest in connection with this paper.

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Received: 26 August 2020 Accepted: 2 March 2021

Published online: 12 March 2021

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