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Biophysical evaluation of the effectiveness of high-frequency bipolar electric welding for closing defects in the *dura mater* in frontal sinus tumours with intracranial spread

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Abstract. One of the main tasks of surgical treatment of patients with frontal sinus neoplasms with intracranial spread is to seal the subdural space, which is achieved by hermetically connected *dura mater*. The purpose of this study was to investigate the structure of the tissues of the *dura mater* and *dura mater*-fascia junction using bipolar electric welding. The methods of light microscopy and infrared spectroscopy were used. When evaluating the results, no β-structured aggregates were observed in the tissue samples under study. There was minimal traumatic damage to the adjacent *dura mater* tissue and minimal thermal damage from vaporisation. Pacchioni granulations, venous pial, and cortical vessels of the *dura mater* were preserved. The study observed complete identity of the wave values of amide A, B, amide I, II spectra; preservation of amide A, B peaks. Preservation and curvature of the N-H arm and O = C - N band were changed within acceptable limits. The findings indicate the absence of β-structured protein aggregates in the junction area, which excludes the possibility of fibrous structures and, as a result, does not contribute to the formation of a meningeal scar. The structure of the collagen protein in the junction area is normal, altered but intact, with preservation of its functions. This indicates the feasibility of using the method of high-frequency bipolar electric welding for surgical closure of defects of the *dura mater*, as an alternative to closure with suture material

Keywords: electrosurgery; infrared spectroscopy; *dura mater* defects; cerebrospinal fluid leakage; cerebrospinal fluid effusion; liquorrhea

INTRODUCTION

One of the most frequent complications of radical removal of frontal sinus tumours with intracranial growth is a disruption of the closed physiological circulation of cerebrospinal fluid (CSF), i.e., the emergence of external and occult CSF liquorrhea. This is caused by insufficient tightness of the closure of defects in the *dura mater* (DM) at the final stage of surgery. These complications can be prevented by using a special method of joining *dura mater* defects using bipolar high-frequency electric welding (HFEW) developed jointly with the E.O. Paton Institute of Electric Welding of the National Academy of Sciences of Ukraine (NAS) [1]. Protein-associated electrothermal tissue adhesion ensures hermetic binding of the tissues of the DM without the use of foreign materials and the formation of a coagulation

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scab. To evaluate the new method of DM connection, special attention should be paid to the structure of the zone of direct tissue connection, its similarity or difference from the surrounding tissues. The answer to this question can be obtained using histological and biophysical methods (confocal infrared spectroscopy).

O.I. Palamar *et al*. [2] found that a violation of the integrity of the *dura mater* during elective neurosurgical and otorhinolaryngological operations causes a risk of developing CSF liquorrhea in the postoperative period with a frequency of 15.9-27.5%. Insufficient sealing of the DM, according to V.V. Kishchuk *et al*. [3], contributes to the leakage of CSF outside the subdural space, resulting in the emergence of external CSF liquorrhea through the surgical wound and other natural openings (otoliquorrhea, rhinorrhea), as well as latent CSF in the form of subaponeurotic accumulation of cerebrospinal fluid, which may stay undiagnosed for some time. One of the main tasks in the surgical treatment of patients with this pathology, according to multiple studies by B. Marlier *et al*. [4], is the sealing of the subdural space, which is achieved by a hermetically sealed *dura mater*. However, if the defect in the *dura mater* is not linear and, when stretched, leads to overstretching of the *dura mater* and compression of the brain tissue, *dura mater* plastics material is required. According to comparative studies by B. Coucke *et al*. [5], autografts are considered to be the ideal material for DM plastics: periosteum, broad fascia of the thigh, temporalis muscle aponeurosis, and only then – synthetic artificial materials.

The newest types of sutures, staplers, shape memory compression devices, diathermocoagulation, biological adhesives, artificial *dura mater* are used to connect *dura mater* defects, but P. Nicolai *et al*. [6] and L. Häni *et al*. [7] found that they cause several complications: persistent infection, focal intense cellular inflammatory reaction, dense encapsulation of foreign material, cerebrospinal fluid, haematomas, rejection reactions, and Creutzfeldt-Jakob disease. A. Kinaci & T.P.C. Van Doormaal [8] found that the negative effects of using sutures to connect the *dura mater* are as follows: leaving foreign material in the tissues, squeezing the tissues that are sutured, which substantially affects the healing process of the wound surface and often causes chronic inflammation in the tissues, allergic reactions to tissues of biological sutures, resulting in wound suppuration, repeated needle trauma, and potentiation of the wound surface by sutures.

Based on the research data of M.M. El-Sayed & E. Saridogan [9], thermal denaturation of proteins – coagulation – occurs when they are heated above 450°C. Coagulation is an inertial process that absorbs energy. The coagulation rate depends on the temperature. T.L. Smith, & J.M. Smith [10] found that living soft tissue should be heated to a temperature at which protein coagulation should end in a few seconds, and the tissue should be clamped with a certain defined pressure. S.S. Podpriatov *et al*. [11] found that with an increase in voltage, the quality of the connection increases, but at the same time, the temperature of the surface layer of living soft tissue between the electrodes increases, which leads to unacceptable thermal damage. In another study, the authors concluded that the reason for this phenomenon is that protein coagulation in cells occurs mainly before the destruction of lipid membranes, i.e., before the formation of a single protein space for the protein to be joined [12]. Thus, an effective technical solution was proposed, which is defined by the fact that to destroy cell membranes before the start of protein coagulation, it is necessary to modulate high-frequency stress with rectangular pulses with a frequency of several thousand hertz.

The purpose of this study was to compare the collagen capacity in the area of the *dura mater* and broad fascia of the thigh after high-frequency bipolar electric welding with the normal collagen structure of the intact *dura mater* and to assess its ability to regenerate in the weld zone.

MATERIALS AND METHODS

The study was conducted in 2018-2022 in the experimental research laboratories of the State Institution "Academic A. Romodanov Institute of Neurosurgery of the National Academy of Medical Sciences of Ukraine". The experiment was performed on 18 porcine cadaveric *dura mater* and 8 porcine cadaveric broad fasciae of the thigh. Immediately after collection, the porcine tissue samples were placed in sterile dishes and thermal bags to preserve the physiological properties of the tissue and delivered to the State Institution (SI) "E.O. Paton Institute of Electric Welding". Then the material was subjected to selected modes of high-frequency coagulation for biological tissue welding using a hardware welding complex in automatic and semi-automatic modes. The study using infrared spectroscopy (IR spectroscopy) was performed jointly with the SI "Institute of Physics of the NAS of Ukraine", Department of Physics of Biological Systems, Kyiv. Histological studies were conducted according to the generally accepted review method of staining histological sections with haematoxylin and eosin.

Four rectangular pieces of 4 × 3 cm were prepared from each porcine *dura mater*. From each porcine broad fascia of the thigh, 6 pieces of rectangular shape 6 × 4 cm were harvested. The animal material was divided into 3 groups (2 experimental groups and 1 control group): the first group was a simulation of high-frequency bipolar electric welding of porcine *dura mater* with porcine *dura mater* (n = 25). The second group was modelling of HFEW of porcine *dura mater* with porcine broad femoral fascia (n = 25). The third group consisted of samples of intact porcine cadaveric *dura mater* (control) (n=30). In Groups 1 and 2, the samples were joined using high-frequency bipolar electric welding in automated modes of the hardware welding complex PATONMED EC 300 M1 (Ukraine) [11].

The obtained samples were immediately fixed in a solution of neutral formalin (sequentially 5-7-10%, 24 hours), dehydrated in ethanol, toluene, and sealed in paraffin (Thermo Scientific Richard-Allan Scientific, Paraffin type 6 REE 8336, Kalamazoo, USA). Sections of 7 µm thickness were made on a HM430 microtome (Microm, Germany), stained with haematoxylin and eosin, picrosirius red (Direct Red 80, Magnacol Ltd, UK) and embedded in balm (Thermo Scientific Richard-Allan Scientific Cytoseal 60, REF 8310-16, Kalamazoo, USA). Microsections were examined using an Axiophot microscope (Carl Zeiss, Germany). The morphometric study of the thickness of the *dura mater* was performed using Carl Zeiss software (AxioVision SE64 Rel.4.9.1, Germany). Tissue samples of 3 groups with a volume of up to 0.5 mm^3 were examined by infrared spectroscopy at 5 points from each compound sample.

To analyse the infrared absorption spectra, thin sections of the post-manipulation tissue were made and dried at room temperature between two CaF2 plates (fluorite glass, transparent in the infrared region). Next, the films on the substrates were placed in the cuvette chamber of the device to record the absorption spectra. The spectra were recorded on a Bruker INVENIO-R spectrometer (Germany) in a wide spectral range (from 3800 to 800 cm^{-1}) at room temperature and humidity of about 60% in a cuvette chamber. The sample under study was placed in one of the interferometer arms or at its outlet in mixed beams.

To obtain the transmission spectrum, the following steps were performed: 1) the interferogram of the free channel (without sample) was recorded. After the Fourier transform, the comparison spectrum R(ν) was obtained; 2) the test sample was placed in the channel and the interferogram with the sample was recorded. After the Fourier transform, the spectrum of the sample S(ν) was obtained. It was similar to R(ν), but with a lower intensity in the absorption regions of the sample; 3) the original transmission spectrum T(ν) was defined as the ratio T(ν) = S(ν)/R(ν). OPUS 4.2 software (Bruker Corp., Germany) was used to analyse the spectral data. All spectra were corrected for the baseline according to the broken line method using 10-15 points, as well as normalised by absorption in the region of the amide bands A, B, I-VII.

The in-plane spectral imaging modes depend on C = O stretching, C-N stretching, N-H stretching, and O-C-N bending, and the out-of-plane mode is conditioned upon the C-N torsion. The characteristic bands of the amide groups of protein chains are similar to the absorption bands of secondary amides in general and are designated as amide bands. There are nine such groups of amides, namely amide A, amide B, and amides I-VII, which are summarised in the table below in descending order of wavenumber (Table 1).

Table 1. Characteristic infrared absorption bands of protein amides

Designation	Wave number (cm^{-1})	Value
A	3300	N-H stretching in resonance with an overtone (2 × amide II)
B	3110	
I	1653	80% C=O stretching; 10% C-N stretching; 10% N-H bending
II	1567	60% N-H bending; 40% C-N stretching
III	1299	30% C-N stretching; 30% N-H bending; 10% C=O stretching; 10% O=C-N bending; 20% other
IV	627	40% O=C-N bending; 60% other
V	725	N-H bending
VI	600	C=O bending
VII	200	C-N torsion

Source: [13]

The amide I and amide II bands are particularly informative for studying protein conformation [13]. Amide I has characteristics including 80% C=O stretching, 10% C-N stretching and 10% N-H bending. Amide II represents 60% N-H bending and 40% C-N stretching.

According to the studies, the characteristic absorption bands of the protein of normal unchanged *dura mater* in the infrared range were determined (Fig. 1), which were used during the study as data for comparison with the indicators obtained during the joining using HFEW [14].

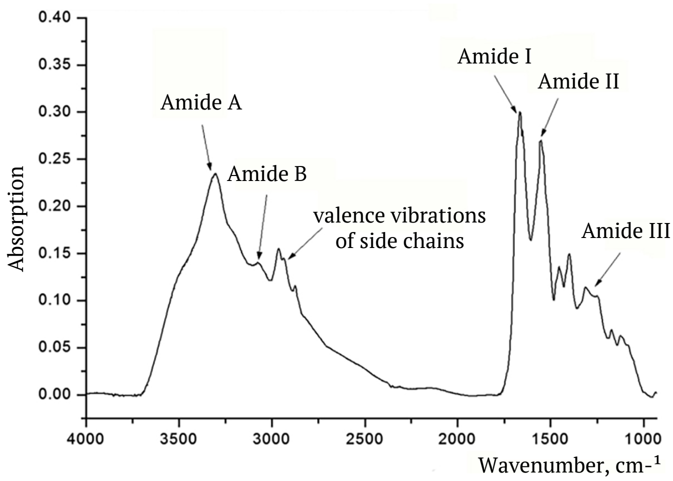

Figure 1. Characteristic absorption bands of normal *dura mater* protein in the infrared range

Source: [14]

Statistical data processing was performed using StatPlus 5.9.9.4/Core v6.7.3 software (AnalystSoft Inc., USA). The hypothesis 76 of a normal distribution in the data samples was tested using the Kolmogorov-Smirnov test.

Between-group differences in data were investigated using one-way analysis of variance followed by the Bonferroni post-hoc test and the non-parametric Mann-Whitney U test. The Pearson linear correlation method was used. All data are presented as mean ± standard error of the mean (M ± m). The difference was considered significant at $P < 0.05$.

The experiment was approved by the Bioethics Committee of the SI "Institute of otolaryngology named after Prof. O. Kolomiychenko of the National Academy of Medical Sciences of Ukraine". Therewith, the principles of bioethics regulated by the Law of Ukraine No. 3447-IV "On the Protection of Animals from Cruelty" [15] and Directive 2010/63/EU "On the Protection of Animals Used for Scientific Purposes" [16] were upheld.

RESULTS

When evaluating the results of a morphological study performed using light microscopy at 400x magnification and haematoxylin-eosin staining, important structural features of the HFEW joining were revealed. Light microscopy of the joining of the *dura mater* with the broad fascia of the thigh (Fig. 2) revealed the interweaving of collagen fibres with the fibrillar structures of the broad fascia of the thigh, which creates a stable weld, and complete preservation of the orientation of collagen fibres, which form the basis of the extracellular matrix skeleton and are the basis of hermetic state. There was no dry coagulation necrosis, which indicates a better prognostic variant of the course of *dura mater* defect healing.

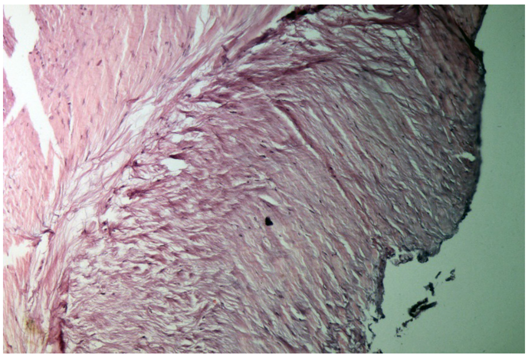

Figure 2. The area of the "welded" *dura mater* suture with the broad fascia of the thigh, haematoxylin-eosin stain, x400
Source: photographed by the authors

The morphological study of the joining of the *dura mater* with the *dura mater* (Fig. 3) revealed heterogeneity in the density of collagen fibres, looseness of the collagen structure, areas of tissue oedema, areas of fibroblast accumulation, and complete preservation of the orientation of the *dura mater* collagen fibres. There is minimal traumatic damage to the adjacent *dura mater* tissue, indicating minimal thermal injury due to vaporisation. The preservation of Pacchioni granulations, venous pial and cortical vessels in the brain tissue indicates the absence of coagulation necrosis. These structures are actively involved in fluid resorption and maintaining the balance of intracranial pressure.

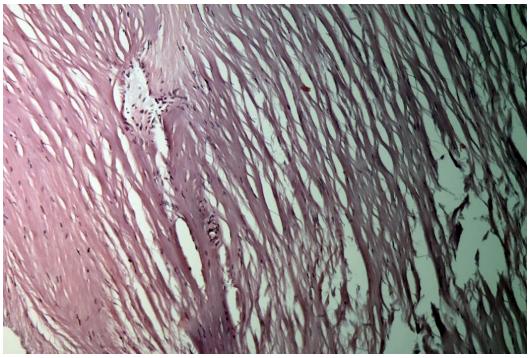

Figure 3. Section of the "welded" suture between *dura mater* and *dura mater*
Source: photographed by the authors

The technique of confocal infrared spectroscopy has made it possible to control the optical properties of biological substances and objects to increase sensitivity and increase the penetration path of visible and near-infrared light photons into deeper regions, which improves the recognition of the molecular structure of the sample under study. When using computer analysis to calculate the relative area of the bands of the components depicted in the amide A and B spectrum (Fig. 4), the results presented indicate that the protein of the thigh broad fascia tissue, connected by HFEW, is almost completely identical to the normal thigh broad fascia tissue. The complete identity of the wave values of the amide A and B spectra, the preservation of the amide A and B peak, the preservation and bending of the N-H arm and the O=C-N band are observed.

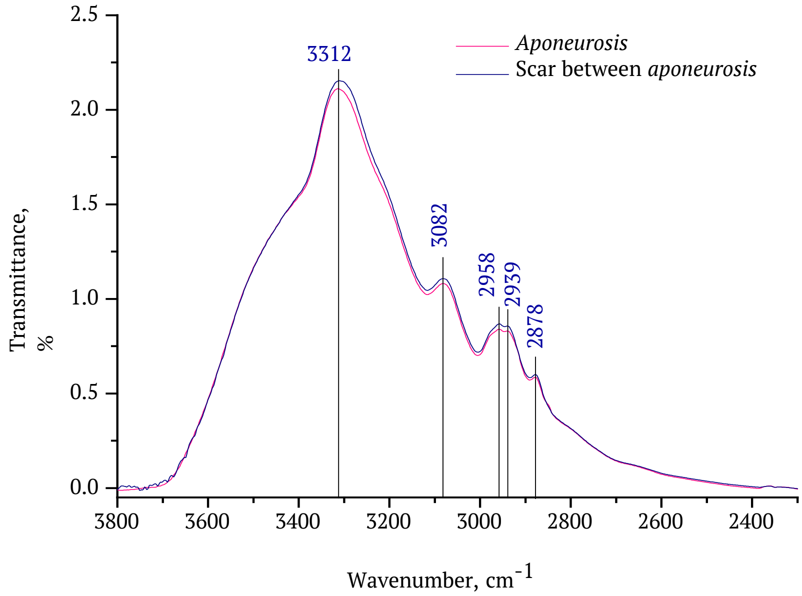

Figure 4. Characteristic absorption bands of amide I and amide II waves of protein of intact broad femoral fascia and broad femoral fascia protein joined by bipolar high-frequency electric welding in the infrared range
Source: compiled by the authors

When using computer analysis to calculate the relative area of the bands of the components depicted in the amide I and II spectrum (Fig. 5), the results presented indicate that the peptides and polypeptides of the broad fascia of the thigh tissue joined by HFEW are almost completely identical to normal broad fascia of the thigh tissue. The complete identity of the wave values of the amide A and B spectra, the preservation of the amide A and B peak, the preservation and bending of the N-H arm and the O = C - N band are observed.

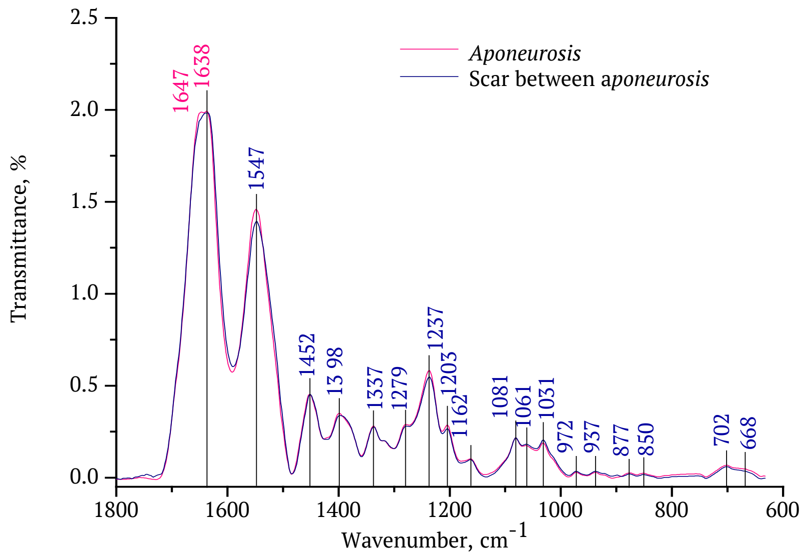

Figure 5. Characteristic absorption bands of amide III waves protein of intact broad femoral fascia and broad femoral fascia protein connected by bipolar high-frequency electric welding in the infrared range
Source: compiled by the authors

The computer analysis used to calculate the relative area of the bands of the components depicted in the spectrum of amide A and B (Fig. 6) indicates that the tissue in the area of HFEW compared to healthy *dura mater* is characterized by a bending of the N-H arm and oscillations of the amide A band (by 0.6 ATR (attenuated total reflectivity)), the characteristic presence of the C = O band of oscillations at 3732 cm^{-1} with the preservation of the amide A peak, the presence of valence vibrations of the side chains shifted by 0.4-0.1 ATR, the presence of overstretching of the CH_2 band in the valence vibrations of the side chains at wave values of 2960-2850 cm^{-1}.

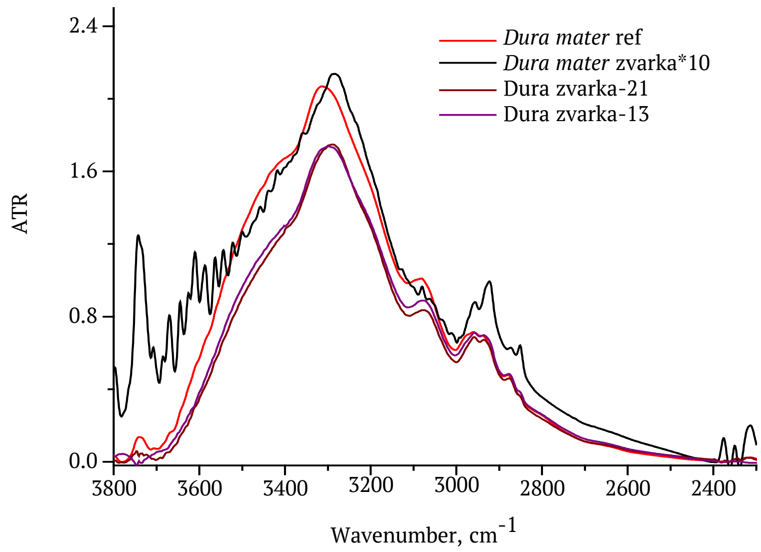

Figure 6. Characteristic protein absorption bands of amide I and amide II waves of intact *dura mater* and *dura mater* protein connected by bipolar high-frequency electric welding in the infrared range
Source: compiled by the authors

In the spectrum of amide I and II for the tissue in the area of the HFEW (Fig. 7) in comparison with healthy *dura mater*, there was a characteristic bend of the NH3+ arm (amino group) in the region of the wave value 1648 cm^{-1} (compared to 1640 cm^{-1} of normal *dura mater* tissue), the absence of an arm in the region of 1640 cm^{-1}, due to which the Amide I band is slightly narrowed and a low-frequency shift of the Amide II band (by 0.4 ATR) is recorded. In the wavenumber region at 1575 cm^{-1}, a low-frequency shift of the Amide II band is observed with no change in the peak, an N-H bending and vibrations in the C-N band (by 0.4 ATR). In the region of the wave value at 1450 cm^{-1}, an asymmetric bending of the CH3 arm is observed with preservation of its value, in the region of the wave value at 1400 cm^{-1}, deformation vibrations of the C = O band and symmetric stretching of the CO_2 band are observed. In the region of the wave value at 1230 cm^{-1}, a bending of the O = C - N arm (by 0.42 ATR) and a bending of the N-H band with the preservation of the Amide III band peak were detected. In the wavenumber region at 1020 cm^{-1} and 1090 cm^{-1}, a 0.01 (ATR) bending of the N-H band is observed with the preservation of the Amide III band peak.

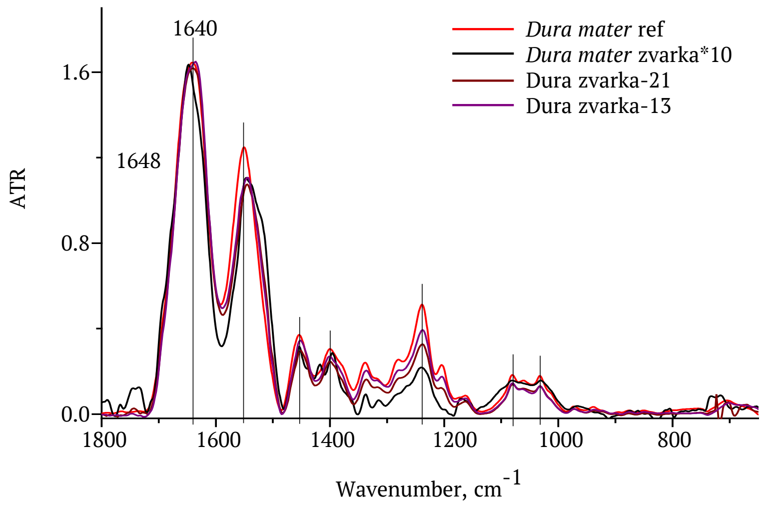

Figure 7. Characteristic absorption bands of amide III waves protein of intact *dura mater* and *dura mater* protein connected by bipolar high-frequency electric welding in the infrared range
Source: compiled by the authors

The results obtained indicate that the regenerative process occurs in the area of joining the *dura mater*, *dura mater* with the *aponeurosis*, and *dura mater* with the broad fascia of the thigh using HFEW instead of charring or coagulation necrosis. When using HFEW in the joint area, the collagen structure and the fibrous structure of the broad fascia of the thigh were changed, but not damaged, and retained their function. Infrared spectroscopy studies showed that the peptides and polypeptides of the *dura mater* associated with HFEW were almost identical to normal intact *dura mater* tissue. The complete identity of the spectral values of the amide A and B waves, the preservation of the amide A and B peaks, the preservation and curvature of the N-H arms and the O = C - N bands were observed.

When comparing tissue samples from the junction of the *dura mater* with the broad fascia of the thigh, joined by HFEW, the identity in the fluctuations of the amide bands A, B is preserved, the maximum spread allowed for the amide peak A, III. Fluctuations in the valence state of the side chains are allowed, and therefore it can be concluded that the structures of proteins (collagen and glycosaminoglycans) in the samples under study are alive, have minor signs of coagulation necrosis, and are capable of regeneration.

DISCUSSION

A. Panteleichuk *et al*. [14] found in their experiment that the presence of the C = O vibration band in the region of 1739 cm^{-1}, the absence of the arm in the region of 1,667 cm^{-1} is characteristic of the *dura mater* scar tissue, due to which the Amide I band in the scar is significantly narrowed and a low-frequency shift of the Amide II band was detected. When evaluating the results of the study, it was found that in the area of the HFEW joining, the C = O vibration band at the joining of the *dura mater* with the *dura mater* shows a arm deformation of 1,400 cm^{-1}, but there are no changes at the above frequencies, which means that there is no deformable scar in the joining area. When assessing the joining between the *dura mater* and the broad femoral fascia, there were no bendings or deformities of the C = O bands compared to the intact broad femoral fascia, indicating absolute elasticity of the connection using the HFEW and no scarring changes.

In the studies of A. Kinaci *et al*. [17], the Amide II wave value in the regions of 1400 cm^{-1} – 1600 cm^{-1} and the fluctuations of the N-H and C-N bands in the limit values from 0.1 to 0.7 ATR are acceptable and do not affect the hermetic state of the tissue. The results obtained during this study show that in the wavenumber region at 1575 cm^{-1} a low-frequency shift of the Amide II band was detected with no change in the peak, N-H bending, and C-N band oscillations (by 0.4 ATR) were observed. An asymmetric bending of the CH3 arm occurred in the region of the wave value at 1450 cm^{-1} with its value preserved, and deformation vibrations of the C = O band and symmetric stretching of the CO_2 band occurred in the region of the wave value at 1400 cm^{-1}, which are permissible according to the authors' studies. Thus, the changes in the C-N, N-H, and CH3 bands obtained in this study are within the permissible range, and therefore the amides of the *dura mater* protein and the broad fascia of the thigh in the area of the junction are biologically active and perform their support functions without the formation of scar tissue.

According to P. Charalampaki *et al*. [18], when examining live tissue samples and studying the wave values of Amide III bands, scar tissue changes and coagulation necrosis of proteins are observed when the O = C - N arm appears at an ATR value above 1.0. For ATR values below 0.9, the O = C - N arm bend is an acceptable variation. The data obtained in this study indicate the presence of a bending of the O = C - N arm (by 0.42 ATR), a bending of the N-H band with the preservation of the Amide III band peak in the region of the wave value at 1230 cm^{-1}. In other words, the wave value describing the state of amide III at the joining using the HFEW is within the permissible limit values and indicates the absence of signs of scarring and vaporisation.

N. Ajayan *et al*. [19] investigated the fluctuations in the spectra of amide A and B. It was found that the fluctuations of the N-H arm, C = O, CH_2 bands in living tissues capable of regeneration should fluctuate within 0.65-0.1 ATR, and when this threshold is exceeded, fibroblasts cannot perform their functions and are prone to the formation of ß-aggregates. The results obtained in this study indicate that in the HFEW region, compared to healthy *dura mater*, there is a characteristic bending of the N-H arm and fluctuations in the amide A band (by 0.6 ATR), the presence of valence vibrations of side chains shifted by 0.4-0.1 ATR, the presence of CH_2 band overstretching (by 0.3 ATR), i.e., in the area of the HFEW joining, proteins are capable of regeneration and there is no formation of scar tissue (namely, ß-aggregates).

H. Mehidine *et al*. [20] found that when describing the results of the wave values of Amide III, the vibration of the N-H and O = C - N bands, while maintaining the support function of the amide and providing its basis for the extracellular matrix, the wave value of the bands should not exceed 0.53 ATR. According to the results of this experiment, in the area of the HFEW joining, the O = C - N arm bending (by 0.42 ATR), the N-H band bending with the preservation of the Amide III band peak by 0.01 (ATR), and the preservation of the Amide III band peak were observed at 1230 cm^{-1}. Thus, the data obtained prove that the joining of the *dura mater* with the *dura mater*, *dura mater* with the broad fascia of the thigh, performed using HFEW, is strong, and the protein in this area is the functioning basis of the extracellular matrix skeleton, which is the basis of hermetic state.

According to the results of the study by A. Jaafar *et al*. [21], an important indicator in assessing the regenerative capacity of tissue is the presence of the NH3+ arm in the spectrum of amide I and II, for sufficient regenerative capacity of globular proteins in the area of the arm emergence, the arm should not exceed 0.5 ATR, which was confirmed by D. DePaoli *et al*. [22]. According to the findings of this study, in the area of HFEW, compared to healthy *dura mater*, there is a characteristic bending of the NH3+ arm in the region of the wave value of 1648 cm^{-1} and in the region of 1640 cm^{-1} with an ATR value of 0.4. In other words, in the area of the joining using HFEW, globular amide I and II proteins are regeneratively capable, which predicts a better course of tissue healing in the postoperative period. Thus, the new method of joining *dura mater* fabrics using high-frequency bipolar electric welding is an effective alternative to joining with suture material (polypropylene).

CONCLUSIONS

Morphological data indicate that regeneration processes occur in the area of joining the *dura mater*, the *dura mater* and the broad fascia of the thigh, performed using HFEW, and not charring or the formation of coagulation necrosis. The structure of the collagen and fibrillar structures of the broad fascia of the thigh after the use of HFEW in the joining area is normal, altered but not damaged, with preservation of its functions. Studies using infrared spectroscopy indicate that the peptides and polypeptides of the *dura mater* connected by HFEW are almost completely identical to normal tissue of the intact *dura mater*. A complete correspondence of the wave values of the spectra of amide A and B was observed, as well as the preservation of the peak for both amides, and the preservation and bending of the N-H arm and the O = C - N band. When comparing tissue samples of the *dura mater* and broad fascia of the thigh, joined by HFEW, the identity in the vibrations of the amide bands A, B is preserved, the permissible maximum change in the peaks of amides A, III, there are vibrations of the valence side chains that are permissible. Thus, it can be concluded that the structure of proteins (collagen and glycosaminoglycans) in the samples under study is alive, with virtually no signs of coagulation necrosis, and capable of regeneration.

The ability of high-frequency bipolar electric welding to connect the *dura mater* tissue and the broad fascia of the thigh, forming a connection that is alive, elastic, tight, and contains collagen that is fully capable of regeneration, was substantiated. Infrared spectroscopy and morphological data indicate that regeneration processes occur in the area of the *dura mater* joining made using high-frequency bipolar electric welding, rather than charring or coagulation necrosis. The structure of the collagen protein in the area of this connection is normal, altered but not damaged, with preservation of its functions.

Future research should aim to develop a thermal resistor that will automatically turn off the bipolar high-frequency welding clamp when the temperature rises above 40 degrees Celsius and causes the threat of thermal damage and vaporisation around the brain tissue.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Біофізична оцінка ефективності застосування високочастотного біполярного електрозварювання для закриття дефектів твердої мозкової оболонки при пухлинах лобних пазух з інтракраніальним поширенням

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Анотація. Одним із основних завдань хірургічного лікування хворих з новоутвореннями лобної пазухи з внутрішньочерепним поширенням є непроникне сполучення субдурального простору, яке досягається герметично з'єднаною твердою мозковою оболонкою. Мета дослідження полягала у вивченні будови тканин з'єднання твердої мозкової оболонки та твердої оболонки з фасцією за допомогою біполярного електрозварювання. Були використані методи світлової мікроскопії та інфрачервоної спектроскопії. При оцінці результатів в досліджуваних тканинних зразках β-структурованих агрегатів не спостерігалося, отримано мінімальне травматичне пошкодження прилеглої тканини твердої мозкової оболонки, мінімальне термічне ураження від вапоризації, збереження грануляцій Паккіоні, венозних піальних і коркових судин твердої оболонки; повна ідентичність хвильових значень спектрів аміду А, В; аміду I, II; збереження піків аміду А, В; збереження та викривлення плеча N-H і смуги O = C - N в допустимих межах були змінені. Результати вказують на відсутність β-структурованих білкових агрегатів у зоні з'єднання, що виключає можливість утворення фіброзних структур і, як наслідок, не сприяє утворенню оболонково-мозкового рубця. Структура білка колагену в зоні з'єднання нормальна, змінена, але інтактна, зі збереженням його функцій. Це свідчить про доцільність використання методу високочастотного біполярного електрозварювання для хірургічного закриття дефектів твердої мозкової оболонки, як альтернативи закриттю шовним матеріалом

Ключові слова: електрохірургія; інфрачервона спектроскопія; дефекти твердої оболонки; витік спинномозкової рідини; ліккворея