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EXPERT SYSTEM FOR SELECTING LOWER-EXTREMITY (THIGH) PROSTHESES AND DIAGNOSIS OF THE QUALITY OF ARTIFICIAL REPLACEMENT. PART I

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1. Purpose and Structure of Expert System. The complexity of the process of artificial replacement of extremities and its crucial significance [5, 9] led to the need to develop an expert system (ES) for prescribing and evaluating the quality of prostheses. The ES described in this article is intended for use under in-patient conditions of medical departments of prosthetic-orthopedic enterprises and departments of artificial replacement of lower extremities when selecting thigh prostheses (in the case of unilateral amputation) and evaluating the results of artificial replacement.

Underlying the concept of developing the system is the representation of the process of artificial replacement (Fig. 1) in the form of a set of the following interrelated stages.

Stage 1. Evaluation of the state of the patient and stump of the extremity being replaced. Determination of absolute relative contraindications to prosthesis.

Stage 2. Treatment of preparation of stump for prosthesis. Elimination of relative contraindications to prosthesis.

Stage 3. Selection of material and components of the prosthesis, parameters of its assembly scheme, assembly, adjustment, and elimination of defects of the prosthesis.

Stage 4. Visual and instrumental (qualitative) evaluation of the quality of replacement. Teaching the use of the prosthesis.

Stage 5. Use of the prosthesis. Accumulation of complaints and comments of patients during use of the prosthesis.

A characteristic feature of this process is the presence in it of two cycles with feedbacks; small cycle containing stages 3 and 4 and large cycle encompassing all stages of the process. The small cycle reflects the process of optimization of the characteristics of the man–prosthesis system by means of adapting the parameters of the prosthesis to the patients on the basis of the results of evaluating the quality of replacement under laboratory conditions. The large cycle reflects the need to correct the characteristics of the man–prosthesis system brought about by possible errors in the small cycle and by possible changes in the state of the patient in stage 5.

It is obvious that the cycles of selection and correction of the characteristics of the man–prosthesis system as the most complex and important elements of the replacement process should be within the "competence" of the ES being created.

An analysis of the meaningful part of the replacement process and its scientific-methodological provision [5, 9] made it possible to formulate the goals whose effective attainment should be promoted by the system being created: elimination of gross errors in the replacement process; improvement of the quality of replacement by using modern methods of objective evaluation of the quality based on the results of measuring the relevant biomechanical characteristics; decrease of the irrational work load of the doctor by automating routine operations.

To attain the indicated goals, it was necessary to realize the following functions in the system: keeping a data file on patients and formation of a scheme for collecting

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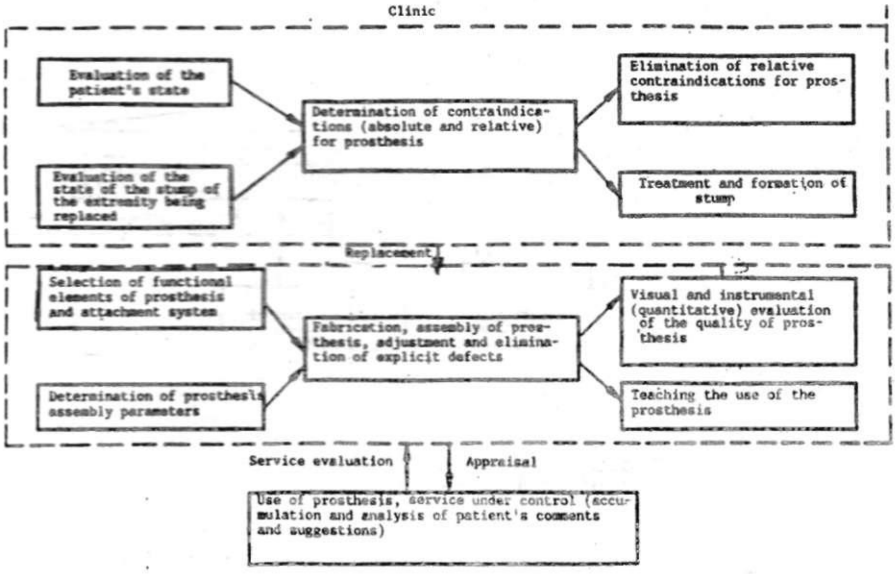

Fig. 1. Block diagram of the replacement process.

data of the patient's medical history; formation of a medical statistical report on the basis of the data file at the request of the doctor; formation of a list of patients to be called for periodic examination at the request of the doctor; formation of variants of components of prostheses and scheme of their assembly with consideration of available supplies; evaluation of the quality of replacement on the basis of semantic data (entered by the doctor into the system on the basis of the results of a visual evaluation of walking on the prosthesis, examination of the stump, and questioning of the patient); formation of a list of possible defects of replacement and recommendations on their elimination; evaluation of the quality of replacement on the basis of the biomechanical characteristics of walking (podography, support reactions, dynamics of interlink angles and measurement of the vacuum pressure in the receiving socket); determination of possible defects of replacement and recommendations on their elimination.

To fulfill the aforementioned functions, an appropriate architecture of the system (Fig. 2) was developed [2, 3, 15], the data base (DB) of which contains: a file of medical data on each patient, including a medical chart, semantic data on the patient's observed defects of replacement and his complaints, data of measuring the biomechanical characteristics of the patient's walking; library of components and schemes of constructing the prothesis; information about the availability of components of the prosthesis; list of absolute and relative contraindications to replacement; library of semantic descriptions of defects of replacement and typical complaints of the patient; library of training selections for determining defects of replacement on the basis of the biomechanical characteristics of walking; library of medical statistical report forms.

With consideration of the stages, the architecture of the developed ES (see Fig. 2) includes four local ESs and conversational interface performing the role of monitor-coordinator. The local systems are realized on modernized "empty" shells [1, 16]. The principle of aggregation and decomposition of structure [20] was used in developing the system for creating hierarchical autonomy of the jobs being performed by the local ESs, providing: automated filling out of the medical charts and obtaining recommendations preceding the replacement process, ES for evaluating the state of the patient and stump; assignment of the code of individual components of the prosthesis with consideration of individual characteristics of the patient – ES for selecting components; issuance of recommendations on selecting the appropriate geometric parameters of assembling the selected components both for average data and for the process of individual replacement by a prosthesis – ES for selecting the parameters of the scheme of assembly of the prosthesis; determination of defects of the prosthesis in the case of unilateral amputation of the thigh by automated logical conclusion using the base of knowledge of the expert-prosthetist, patient's complaints, and observations of the doctor-user – ES for evaluating the quality of replacement (EQR). The ES also contains apparatus measuring the biochemical characteristics of the patient's

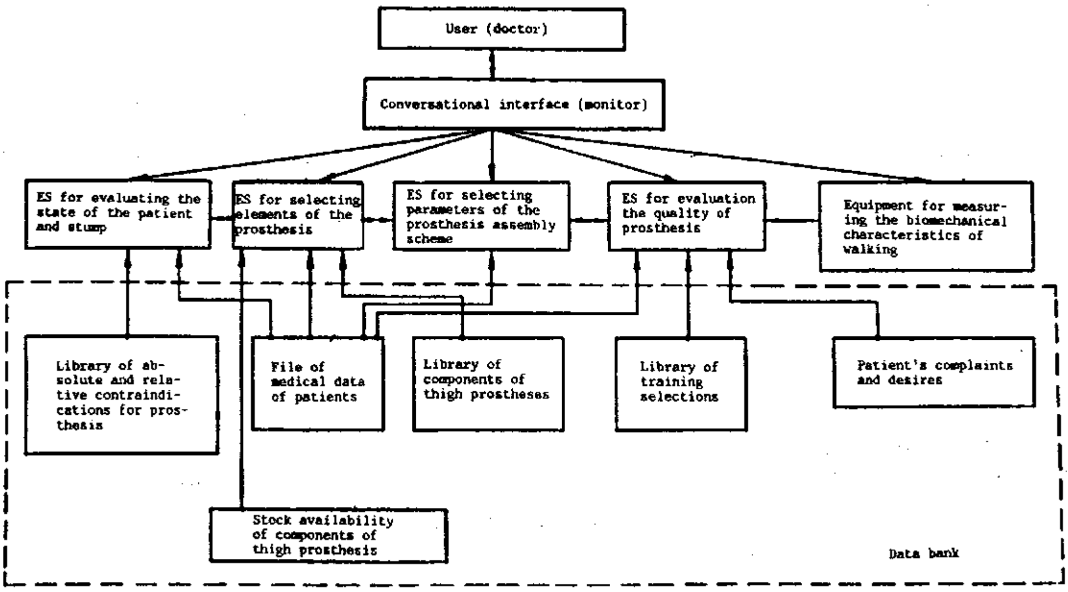

Fig. 2. Architecture of the expert system (ES).

walking, using the DB of developments [4-6, 9-12] containing an interpretation of possible effects of the prosthesis with respect to the following parameters: podography, support reactions, dynamics of interlink angles, and measurement of the vacuum pressure in the receiving socket.

The following was a significant feature of the replacement process, consideration of which led to the creation of a nontraditional hybrid ES [2, 3, 15].

Whereas the local ESs corresponding to the first three stages are intended for rational selection of elements of the prosthesis and parameters of its assembly scheme, the fourth ES provides an evaluation of the quality of functioning of the man–prosthesis system. Here it is necessary (at the stage of extracting knowledge and developing an interpretation of possible defects on the basis of the observed signs) to take into account the individual characteristics of the patient, to use subjective evaluations (of the doctor and patient), and to separate them from objective signs obtained during an instrumental biomechanical investigation. The specifics of individual stages of the replacement process required combining various methods of presenting knowledge [14] (including frame and production formalisms), as well as various methods of presenting fuzzy knowledge [7] in a linguistic description of defects of the prosthesis and patient's complaints. This in turn imposed demands on the logical conclusion schemes. (probabilistic and fuzzy conclusions are used in the system). The use both of direct and inverse logical conclusions is a special feature (from the viewpoint of constructing the ES).

As a result, a second-generation hybrid ES was developed with a deep representation of knowledge [2, 3, 15] meeting the requirements imposed on such ESs [7, 8, 14, 17-19, 21-27].

2. Structure and Tasks of Problem-Oriented Local ESs. The characteristics of the operation of local ESs are described in conformity with the presented general structure of the ES (see Fig. 2) and stages of replacement (Fig. 1).

2.1. ES for Evaluating State and Stump of the Patient. The unit determining contradictions with respect to functional purpose includes an evaluation of the state of the cardiovascular system, evaluation of the state of the stump, evaluation of the state of the preserved extremity, as well as the development of recommendations on the regime of motor activity and medical supervision.

As a result of the examination, contraindications for a prosthesis are revealed and recommendations are given on additional treatment leading to improvement of various characteristics of the state of the patient. Absolute and relative contraindication are possible (in a number of cases absolute contraindication can be interpreted as relative).

Clinical examinations for diseases of the cardiovascular system include the following

```
IF START, THEN DISPLAY ("
CONTRAINDICATIONS FOR PROSTHESIS WITH RESPECT TO STATE OF STUMP
ARE EVALUATED FROM THE FOLLOWING POSITIONS:
1.  State of blood circulation of stump (from data of special investigations)
2.  Defects and diseases of soft tissues of stump
3.  State of nervous system of stump
4.  State of bone part of stump
5.  State of hip joint
6.  Stump without deviations
INTRODUCE NUMBER OF CORRESPONDING POSITION") AND REQUEST(position);
IF position = 2, then display ("
    Deviations of tissues and systems of the stump from a normal state
are expressed by the presence of diseases and defects of the stump
- Skin pathologies:
1.  Granulated wounds of stump
2.  Ulceration and tropic ulcers
3.  Scar lesions of stump
4.  Inflamed sores
5.  Chafing
6.  Hyperkeratosis
7.  Bursitis, frayed trauma
8.  Excessive sweating of the skin, intertrigo, maceration");
9.  Folliculitis, pyoderma, and other inflammatory skin diseases
10. Dermatitis, dermatosis, eczema
11. Allergic skin diseases
12. Excess of soft tissues in distal part of stump
13. Edema of distal part of stump
14. Phenomena of acute and chronic lymphovenous congestion
15. Clavate stump (due to soft tissues)
16. Ligature fistula
17. Soft-tissue ridge above seating stump");
    - Muscle pathology:
18. Pronounced atropy of muscles, including muscles of above-lying segment
19. Paralysis of stump muscles and above-lying segment
INTRODUCE NUMBER OF OBSERVED DEVIATION") AND REQUEST(number of soft tissue);
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b

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IF number of soft tissue = 1, then DISPLAY("Presence of wound is absolute contraction
to prosthesis.  Patient should be sent for treatment");
IF number of soft tissue = 2, then DISPLAY("In the case of ulveration or tropic ulcer,
long conservative or surgical treatment is indicated; cutis plate, radical excision
with replacement by sound tissues");
IF number of soft tissues = 3, then DISPLAY("In the case of scar lesions of the skin,
excision of the scarred parts of the stump is indicated with the use of the skin graft
method.  In the case of extensive scarring of the skin, the use of a prosthesis is
practically impossible");
IF the number of soft tissue = 4, then DISPLAY("A sore is developing as a result of
extreme local pressure from the side of the receiving socket. It is characterized by
hyperemia, edema, and tenderness of the skin.  It is necessary to eliminate the cause of
the sore, to carry out treatment, during which the use of the prosthesis is not recom-
mended and to make additional adjustments of the prosthesis");
IF the number of soft tissue = 5, then DISPLAY("Surface damage of skin occurs as a result
of excessive friction during walking on the prosthesis.  Treatment is traditional, during
which the use of the prosthesis is limited");
IF the number of soft tissue = 6, then DISPLAY("Hyperkeratosis occurs as a result of long
effect on the skin, local, tolerable, but exceeding the physiological limits of the skin");
IF the number of soft tissue = 7, then DISPLAY("Anti-inflammatory treatment is recommended
in the stage of exacerbation.  Surgical treatment is recommended in the cold period: exci-
sion of bursa or frayed trauma.  Rational prosthesis is indicated for the purpose of pre-
venting the formation of new bursitides and frayed traumas");
IF the number of soft tissue = 8, then DISPLAY("Indicated: regular care of the stump, treat-
ment of the skin with tanning agents");
IF the number of soft tissue = 9, then DISPLAY("Indicated: treatment of skin with disinfec-
tants, ultraviolet irradiation, etc.  Observance of hygienic care of the stump is mandatory");
IF the number of soft tissue = 10, then DISPLAY("Presence of the data of disease is a contra-
indication to prosthesis during treatment");
IF the number of soft tissue = 11, then DISPLAY("Drug treatment is indicated in the case of allergic
skin diseases");
IF the number of soft tissue = 12, then DISPLAY("In the case of an excess of soft tissues
in the distal part of the stump, excision is recommended");
IF the number of soft tissue = 13, then DISPLAY("Treatment is recommended in the case of
edema of the distal part of the stump.  Prosthesis is contraindicated temporarily");
```

Fig. 3

IF the number of soft tissue = 14, then DISPLAY("Irrational prosthesis is the cause of acute or chronic lymphovenous congestion. Additional preparation of the receiving socket is recommended in acute cases of congestion for the purpose of eliminating extreme compression of the stump tissue. In the case of chronic lymphovenous congestion, conservative combined treatment is indicated before replacement. Full-contact receiving sockets are made for therapeutic and prophylactic purposes");
IF the number of soft tissue = 15, then DISPLAY("In the case of a clavate stump (due to soft tissues) it is necessary to carry out preparatory treatment to reduce the clavate shape: phantom pulsed gymnastics of the stump, massage of a suctioning character, rational bandaging of the distal part of the stump by an elastic bandage, walking on a therapeutic training prosthesis");
IF the number of soft tissue = 16, then DISPLAY("In the case of a ligature fistula, the patient should be sent to surgery to eliminate the fistula");
IF the number of soft tissue = 17, then DISPLAY("Rational prosthesis is recommended: fabrication of a receiving socket with optimal correspondence to its dimensions with fitting of excess tissues inside the receiving socket");
IF the number of soft tissue = 18, then DISPLAY("In the case of atropy, conduct electrostimulation of muscles. It is necessary to prescribe a lightweight prosthesis");
IF the number of soft tissues = 19, then DISPLAY("In the case of paralysis of the stump muscles, thorough preparation of the prosthesis with optimal attachement is necessary");

Fig. 3. Example of the base of knowledge (BK) of the local ES for evaluating state of the patient and stump: a) fragment of the list of states of the stump; b) examples of the decision-making rules when evaluating the state of the stump.

stages: detection of diseases (with and without additional examination); absolute and relative contraindications are revealed; issuance of recommendations on additional treatment; evaluation of the state of the patient of the basis of a number of signs; evaluation of the functional reserve of the cardiovascular system.

An evaluation of contraindications with respect to the state of the stump reveals pathological changes in the blood circulation of the stump (from data of special investigations), defects and diseases of soft tissues, and state of the bone part of the stump, as well as the state of the hip joint.

A list of possible pathologies is issued in the form of a menu for each of these signs. Depending on the degree of pathological deviations, the ES issues the appropriate recommendations, including a set of therapeutic and surgical measures and recommendations on the choice and use of the prosthesis. A fragment of the base of knowledge (BK) representing a list of evaluations of the states of the soft tissues of the stump and corresponding decision-making rules is shown in Fig. 3a, b.

Example 1. Several patients with various states of the stump were examined by means of the unit revealing contraindications. Thus, considerable scarring of the skin was observed in patient S. The use of a prosthesis with this state of the stump is practically impossible. The system recommended: excision of the scarred parts of the stump with the use of the skin flap method.

A clavate stump (due to soft tissues) was observed in patient K. The system recommended for him: preparatory treatment to reduce the clavate shape of the stump (phantom impulse gymnastics of the stump, massage of a suctioning character, efficient bandaging of the distal part of the stump by an elastic bandage, walking on a therapeutic-training prosthesis).

The data of special investigations obtained on the state of blood circulation of the stump make it possible to refine the functional state of the stump as a result of the pathological process and to introduce, if necessary, corrections in the recommendation.

2.2. ES for Assigning Components and Selecting Parameters of the Thigh Prosthesis Assembly Scheme. The general scheme of assigning components of the prosthesis and determining the parameters of the assembly scheme is given in Fig. 4.

The process of selecting components of the thigh prosthesis reduces to selecting the material of the receiving socket 1, type of attachment 2, type of knee mechanism 3, material of the foot 4, type of ankle 5, and codes of the prothesis and its components (Fig. 4).

Each stage is characterized by a distinct decision space. Elements of the prostheses are selected on the basis of an analysis of the anthropometric data on the patient, case history, examination of the state of the stump of the limb being replaced and the medium surrounding it. It is necessary to note that the local problem is solved at each stage, and the stages are interrelated so that the result of solving a particular problem deter-

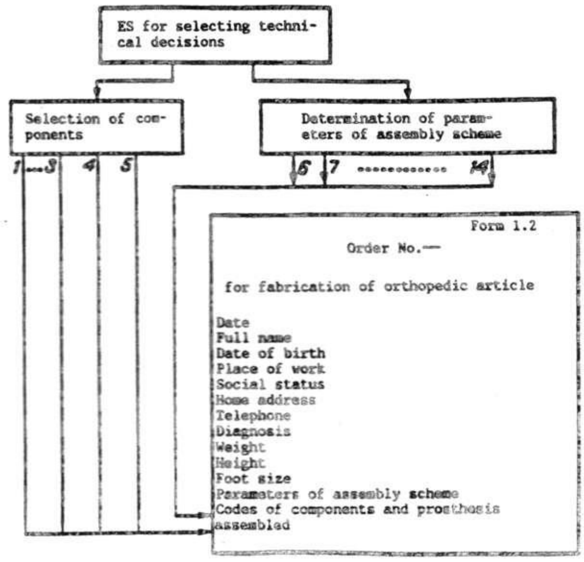

Fig. 4. Structure of ES for selecting components and assigning parameters of prosthesis assembly scheme. Explanation in text.

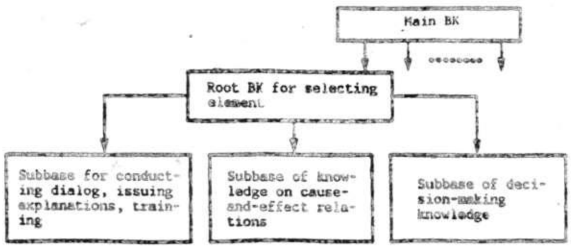

Fig. 5. Structure of BK of ES for selecting components of prosthesis.

mines the initial conditions for solving the next problem.

Figure 5 shows the structure of the BK of the given local ES. The BK includes a set of cause-and-effect relations supplied with reliability factors for taking into account elements of uncertainty of knowledge. One of the fragments of the BK is shown in Fig. 6a. Direct production chains of reasoning are realized in the model. Depending on the given conditions, new sets of productions are formed, making it possible to generate hypothesis with a given degree of reliability.

The model of the dialogue is intended for the untrained user, it has a hierarchical structure, and includes protection from syntactic errors. The variant of operation of the ES in the user training mode includes a set of explanations as decisions are being made. During the time of solving the problem, the successive use of new information makes it possible to narrow the space of possible hypothesis, to reveal the most prospective solutions, and to eliminate unlikely ones.

The process of the user's consultation with the system includes: 1) selection of the goal (subgoal); 2) explanations on selecting the goal; 3) request for current data; 4) search for solutions in the BK; 5) bringing up the most preferable solutions by the system; 6) issuance of the results to the user; 7) obtainment of explanations on the use of the recommendations obtained; 8) request for additional conditions of the feasibility of the recommendations; 9) final making of the most preferable decision by the doctor; 10) entry of the results of the DB: a) values of the parameters of the patient; b) results of operation of the system; c) doctor's decision.

The extra- and intramachine information support of the ES includes: formation of the structure of the information — hypotheses in the form of a "black box;" matrices presented to the expert for establishing the reliability of the cause-and-effect relations; input, intermediate, and output documents, set of DB.

a

IF ABDUCENT CONTRACTURE
THEN WOODEN COMPONENT
RELIABILITY 30;

IF ABDUCENT CONTRACTURE
THEN UNIAXIAL ARTICULATE
RELIABILITY 5;

IF ABDUCENT CONTRACTURE
THEN UNIAXIAL ARTICULATE TO
WORKING PROSTHESIS
RELIABILITY 5;

IF ABDUCENT CONTRACTURE
THEN BIAXIAL WITH AUTOMATIC
FIXATION
RELIABILITY 5;

IF ABDUCENT CONTRACTURE
THEN POLYCENTRIC
RELIABILITY 90;

IF ABDUCENT CONTRACTURE
THEN SUPERPOSED KNEE HINGES
RELIABILITY 5;

IF ABDUCENT CONTRACTURE
THEN WITHOUT KNEE HINGES
RELIABILITY 5;

b

receiving socket material
2
plaster
0.999
laminated plastic polyester binder
1.000
laminated plastic polyamide binder
1.000
metal
0.800
wood
0.800
leather
−0.197
nitrocellulose lacquer
0.986
molded polyethylene
0.700
maximum prepared polyethylene
0.008
from polycarbonate
0.289
metal-plastic
0.171
from polyvic
0.227

c

type of knee component
4
uniaxial inarticulate
0.640
uniaxial articulate
0.440
wooden component
0.580
polycentric
0.500
superposed knee hinge
0.800
uniaxial articulate
working prosthesis
0.235
biaxial with automatic
fixation
0.280
without knee hinge
0.145
hinge with adjusting device
0.500

d

type of attachment
11
waist attachment
1.000
waist attachment with anterior
lacing and posterior flap
−0.990
corset attachment
0.650
corset attachment with braid
support
−0.900
harness support
0.000
attachment to bodice
0.000
Shuvalov's construction
0.900
attachment to half-corset
−0.990
strap attachment
−0.990
vacuum attachment
0.000
nonfalling receiving socket
1.000
combined attachment
0.000
waist attachment with metal
pivot
0.001

e

extremity
2
wooden ankle
0.000
metal ankle
1.000
without ankle
0.000

f

extremity
1
from polyurethane
0.552
rubber
−0.246
felt
−0.341
stamped metal
0.885
without foot
0.230
others
0.181

Fig. 6. Examples of fragment of BK and ES and results of selecting components of prosthesis: a) fragment of BK for selecting type of knee component with consideration of contracture of stump; b) example of selection of receiving socket material; c) example of selection of type of knee component; d) example of selection of type of attachment; e) example of selection of type of ankle; f) example of selection of type of foot.

Such a structure of the BK makes it possible to solve multicriterion problems of selecting components of a prosthesis in a conversational mode. Figure 6 (b-f) shows the results of selecting components of the prosthesis with various degrees of reliability of the decision being made.

Determination of the parameters of the assembly scheme reduces to finding the mutual arrangement of components of the prosthesis and locomotor apparatus of the invalid. The following parameters are determined (see the notations in Fig. 4): 6) horizontal outward movement of the middle of the axis of the knee joint (KJ) or knee hinge (KH) relative to the middle of the axis of the ankle hinge (AH); 7) horizontal outward movement of the middle of the frontal diameter of the hip socket relative to the vertical passing through the middle of the axis of the AN; 8) horizontal backward movement of the axis of the KJ or KH in the sagittal plane relative to the axis of the AH; 9) horizontal forward movement of the center of the flat template of thigh socket in the sagittal plane relative to the axis of the AH;

```
DES("Y_2", "Y_2", 0, 1,"");
DES("lam", "Level of amputation", 0, 1, "");
DES("atroph", "Atrophy of stump", 0, 1,"");
DES("sex", "Sex", 0, 1,"");
DES("X_2"), "Amount of divergence X_2", 0, 1, "");
DES("siz_foot", "Size of foot", 0, 1,"");
DES("Y_2", "Extension of thigh Y_2") 0. 1"");
DES("type_attach", "Type of attachment", 0, 1, "");
DES("a", "Rotation of thigh a", 0, 1, "");
DES("weight", "Weight", 0, 1, "");
DES("weight prosth", "Weight of prosthesis", 0, 1, "");
DES(in_fr", "Angle of slope of thigh socket axis in frontal plane in_fr", 0, 1, "");
DES("in_sag", "Angle of flexion of thigh socket device in saggital plane in_sag", 0,
 1, "");
DES(p,p);
IF START, THEN READ_PO("d:/sever/daria/medcard/medk");
IF START and age = 1 OR 2 OR 3 OR 4, then BK(det);
IF START and age = 5 OR 6, then BK(av);
IF START and age = 7 OR 8 and subgroup = 1, then BK (star1);
IF START and age = 7 OR 8 and subgroup = 2, then BK (star2);
IF p and det, then #BK (det) and BK (publ);
IF p and av, then  #BK(av) and BK(publ);
IF p and star1, then #BK(star1) and BK(publ);

IF av, then DISPLAY("Calculation is made for average age group");
IF av, then MENU(type_attach, "1. Vacuum", "2. Without vacuum");
IF av and lam = 1 OR 2 and atroph = 1 and sex = 1, the X_2=29;
IF av and lam = 3 and atroph = 1 and sex = 1, then X_2=28;
IF av and lam = 4 and atrop = 1 and sex = 1, then x_2=29'
IF av and lam = 5 and atroph = 1 and sex = 1, then x_2= 30;
IF av and lam = 6 and atroph = 1 and sex = 1, then X_2=34;
IF av and lam = 7 OR 8 and atroph = 1 and sex = 1, then X_2=40;

IF av and lam = 1 OR 2 and atroph = 2 and sex = 1, then X_2=19;
IF av and lam = 3 and atroph = 2 and sex = 1, then X_2=20;
IF av and lam = 4 and atroph = 2 and sex = 1, then X_2=23;
IF av and lam = 5 and atroph = 2 and sex = 1, then X_2=26;
IF av and lam = 6 and atroph = 2 and sex = 1, then X_2=31;
IF av and lam = 7 OR 8 and atroph = 2 and sex = 1, then X_2=39;

IF av and lam = 1 OR 2 and atroph = 1 and sex = 2, then X_2=28;
IF av and lam = 3 and atroph = 1 and sex = 2, then X_2=29;
IF av and lam = 4 and atroph = 1 and sex = 2, then X_2=31;
IF av and lam = 5 and atroph = 1 and sex = 2, then X_2=35;
IF av and lam = 6 and atroph = 1 and sex = 2, then X_2=40;
IF av and lam = 7 or 8 and atroph = 1 and sex = 2, then X_2=43;

IF av and lam = 1 OR 2 and atroph = 2 and sex = 2, then X_2=19;
IF av and lam = 3 and atroph = 2 and sex = 2, then X_2=20;
IF av and lam = 4 and atroph = 2 and sex = 2, then X_2=23;
IF av and lam = 5 and atroph = 2 and sex = 2, then X_2=26;
IF av and lam = 6 and atroph = 2 and sex = 2, then X_2=31;
IF av and lam = 7 OR 8 and atroph = 2 and sex = 2, then X_2=39;
IF publ, then DISPLAY("Recommended parameters of assembly scheme")

      and DISPLAY(X_2)
      and DISPLAY(Y_2)
      and DISPLAY(a)
      and DISPLAY(in_fr)
      and DISPLAY(in_sag)
```

b

```
  Recommended parameters of assembly scheme
Amount of convergence X_2=28 mm
Extension of thigh Y_2=6 mm
Rotation of thigh a=13 deg
Angle of slope of thigh socket axis in_fr=1.5 deg
Angle of flexion of thigh socket device in_sag=6 deg
```

Fig. 7. Examples of BK of ES for determining parameters of prosthesis assembly scheme: a) fragment of BK; b) example of assigning parameters of assembly scheme.

10) angle of outward rotation of the projection of the axis of the AH onto the horizontal plane relative to the projection of the axis of the KJ or KH onto this same plane; 11) angle of inward rotation of the thigh; 12) angle of slope of the axis of the thigh socket in the frontal plane; 13) angle of slope of the axis of the thigh socket in the sagittal plane; 14) rotation of the foot.

As is known, there are various methods of determining the scheme of constructing prostheses [13]. The method of the Central Research Institute of Prosthetics was used in the investigated version of the system [5, 9]. The system, however, is open and makes it possible (if necessary) to use any of the existing [13] methods. Figure 7a, b shows fragments of the BK and recommended parameters of the prosthesis assembly scheme for patient A.

The ES diagnosing and evaluating the quality of prosthesis is examined in the second part of the article and general conclusions are given.

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