

#### EXPERIENCES WITH HYBRID SYSTEM

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#### S u m m a r y

Most of the former aspirations in Prosthetics were directed towards the application of new materials and components. The problems concerning the control systems have not followed the mentioned innovations, but practically remained at the level of classical solutions of some decades ago.

At the cases of upper extremity high amputation levels, followed by great functional losses, a complex problem of control and power supply of prosthetic device has emerged. In attempt to solve this problem, the modern Prosthetics pointed out to hybrid approach of using the combinations of external power sources as well as the residual functional and energetical potentials of patient himself.

This paper presents our experience in application of hybrid prosthesis with a mechanical elbow unit, driven by the patient's own strenght, and an electrical hand, powered by separate battery.

C o m p a r a t i v e   r e v i e w

Following a period of various mechanically active prosthetic components, the last two decades have been filled up with investigations on use of the myoelectric control. This way of control, as the most similar to the natural one, has proved to be highly efficient when the naturally predetermined muscle groups have been used as the source for the control signal, with the aim of realizing the appropriate movement of prosthetic device. However, the experience has revealed that disadvantages of such a way of control emerged in all cases where it was necessary to use a greater number of control sites, or when signals were taken from muscles which function is not naturally predetermined for requested movement. Besides that, the myoelectric control is sensitive to disturbances within the stronger electromagnetic fields, limiting thus the indicative area of its application.

The electronic hands with feedback, have aroused the great interest, particularly due to the attempt of the imitation of natural sensomotor mechanism. However, not only due to the present insurmountable technological obstacles in realization of the artificial neuron networks, but also due to indistinct ideas on the use of information obtained by the feedback system, the wider practical application to the patients has not been achieved.

### Our experiences

Our long term experience with patients, and work with various types of prostheses in clinical application, have brought us to actual needs of the patients. Our aim was to realize, according to the available principles and technology, a simple and acceptable solution in the cases of the above-elbow amputees. For that reason in the course of 1974, in the Center for Prosthetics, Beograd, the hybrid prosthesis was realised, consisting of the mechanical elbow joint with a lock, powered by the patient himself, and the electromechanical hand, powered by a battery. (Lit. /1/.).

The applied hybrid system has the following characteristics:

- The articulation of the fingers is at the metacarpophalangeal joints level, with tripod hook system with ulnar deviation of the middle finger of about  $5^{\circ}$ , and the radial deviation of the index finger of about  $12^{\circ}$  while opening, as well as convergence in closing followed by the thumb opposition (adapted mechanical construction of Viennatone hand with standard motor and battery).
- The "bang-bang" control system is applied, using the micro-switches build into the so-called hybrid transducer of the electromechanical type. Due to the sufficient inertia of the gear mechanism, the operation of the hand is smooth and without jerking.

When controlling such an unifunctional terminal device in the composition of the hybrid system, it is necessary to determine only the direction of movement of the actuator and the time of its engagement. In combination with the mechanical elbow, the

hybrid system is functioning in the following way:

Primarily, the patient by humeral flexion through the Bowden cable brings the forearm to the desired position, then by humeral extension locks the mechanical elbow and, finally, by prolonged action, through the scapular abduction, via Bowden cable, activates the hybrid transducer for the control of the electro-mechanical hand.

The hybrid transducer is located in the forearm of prosthesis, and is connected with the Bowden cable approximately at the same level as in the case of mechanical hand. Thus way a quick and easy change of terminal devices if necessary, has been obtained.

#### Standard evaluation

After finishing and assembling the hybrid system, the first patients were fitted, and following the training period, they undergone the standard evaluation procedure. (Lit. /2/.).

As a comparative terminal device the standard Dorrance mechanical hand was applied.

Interpretation of the evaluation tests, indicates that the time of performance with electromechanical hand is slightly longer in average, what has been to our opinion, caused by characteristics of driving motor and mechanical gear. The number of errors is smaller when applied the electromechanical hand, especially concerning the compression errors.

The other advantages of hybrid approach, noticed during the work with the patients, are concerning the following:

- Reliability in the voluntary control of opening and closing of hand.
- Minimal training period, because the patient trained previously for the work with the mechanical prosthesis, used still the learned control scheme.
- Reduced effort for activation of the terminal device and greater grasping force compared to the mechanical hand.
- Application to the patients, where, because of high functional loss, mechanical prosthesis could not be efficient.
- Homogenous control system with unique command site.
- Unresponsiveness to the influence of electromagnetic field and reliability in operation (the hybrid transducer was tested to 500.000 cycles of activation, without any failure).
- Simplicity in completing the prosthetic system.

### C o n c l u s i o n

The fitting of patients with the hybrid prosthesis has been applied as a routine procedure in the Center for Prosthetics. Until now, the 12 patients from our country and abroad have been fitted, and they come periodically for checking out the state of their prostheses. Except the failures related to durability of components, there were not noticed any functional shortcomings. The patients expressed their favourable subjective opinions about the value of the prosthesis, what had influenced their psychological attitude and acceptance.

The up-to-date experiences obtained during the application of the hybrid prosthesis, could not be considered as definite.

The future practice in regular fitting and possibilities of the new applications will provide a more complete estimation of the functional value of the hybrid approach.

#### L i t e r a t u r e

- /1/. Ivančević N., Kajganić M.: Hybrid prosthesis of arm, World Congress of Prosthetics and Orthotics, October 1974, Montreux, Suisse.
- /2/. Kajganić M., Zotović B.: Functional evaluation of the Beograd Hand Prosthesis, The final report of a study, Center for Prosthetics, Beograd 1972.

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