New Computerized Elbow and Forearm Clinical Scores

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Abstract

Background Current elbow clinical scores are scarce with limited comparability between them. None of them are computerized yet. There is no forearm clinical score assessing all anatomical components of forearm disorders such as the Essex-Lopresti injuries. The aims of this paper were to present new computerized elbow and forearm clinical scores.

Methods These new computerized elbow and forearm clinical scores include four clinical criteria: pain, function, active range of motion and muscle strength. To each criterion is given a numerical value among 5 grades. The weight of each criterion is equivalent so that patient's and physician's related scores are equally balanced.

Results Clinical scores components are automatically included into diamond-shape graphs and tables that can be directly exported into PowerPoint presentations for demonstration and comparison purposes.

Discussion These user-friendly updatable clinical elbow and forearm scores are based on four classic clinical criteria, pain, function, motion, and strength that are expressed into grades. They were designed to evaluate any osteoarticular elbow or forearm disorder regardless of the etiology. These scores are open since they may be modified in future versions.

Keywords
- Clinical Score
- elbow
- forearm
- evaluation
- outcomes

Assessment of patient's specific clinical status before and after treatment is a critical part of any osteoarticular clinical research. Modern articular clinical scores should be computerized.[1] They should include patient's assessment of pain and function, and physician's assessment of active range of motion and strength (muscle power) in a well-balanced weight ratio. If a joint includes several articular components, each of them should be considered in the scoring system.

Current elbow clinical scores are scarce[2] with a lack of comparability between them.[3] None of them are computerized yet. Since 1999 we have been using a computerized elbow clinical score including evaluation of pain, function, active range of motion, strength and assessing not only the humeroulnar joint but also the proximal radioulnar joint (PRUJ).

To the best of our knowledge, there is no forearm clinical score assessing all anatomical components of forearm disorders such as the Essex-Lopresti injuries. A computerized forearm clinical score including evaluation of pain, function, active range of motion and muscle strength should assess not only the humeroulnar joint but also the PRUJ, DRUJ, and radiocarpal/midcarpal joints.

We recently published a computerized clinical wrist score[4] including evaluation of pain, function, active range of motion and muscle strength assessing not only the

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radiocarpal/midcarpal joint but also the distal radioulnar joint since it is an important component of the wrist.

The aims of this paper were as follows:

1. To present our computerized elbow clinical score.
2. To present a new computerized forearm score based on a similar format and allowing a comprehensive clinical evaluation of the forearm disorders as the Essex-Lopresti injuries.

Methods

Elbow Score

This new computerized elbow clinical score (Lyon Elbow Score, LES) includes four clinical criteria: pain, function, active range of motion, and muscle strength. To each criterion is given a numerical value among 5 grades (from normal function to complete disability: 20–15–10–5-0). Thus, no pain, normal function, normal active motion, and strength are rated as 20 points each, providing a total which is converted as a percentage to define a numerical computerized score. The higher the percentage is, the better is the clinical result. The LES form is displayed in ►**Fig. 1**.

The weight of each criterion is equivalent so that patient's and physician's related scores are equally balanced.

The surgeon's assistant only needs to fill out the pink colored boxes (data boxes) in an excel file during patient's examination. Yellow calculations boxes, radar diagrams, and a yellow summary table are automatically generated.

Both elbow pain and function are evaluated by the patient on visual analog score and grade rating scales from 0 to 20. Elbow function is self-assessed according to patient's needs whether they are basic daily living, work, or sports-related activities. Visual grading assessment of elbow function is a validated method.[5] Since the elbow is a combination of both humeroulnar and humeroradial joints, not only elbow flexion-extension are assessed but also forearm rotation for pain and capacities.

Goniometric measurements of active range of motion in degrees include elbow flexion-extension and forearm prono-supination. Data of active range of motion are then automatically summed in the yellow calculation boxes and then converted to the corresponding value among the 5 grades. The distribution of active motion grade is displayed in ►**Fig. 1**.

In this first version of LES, elbow muscle strength is recorded according to the Medical Council Research (MRC) system. Elbow muscle strength MRC value is entered in a dedicated data box and automatically converted into elbow muscle strength grade.

Forearm pronation and supination strength is measured in kilograms using a specific dynamometer (Baseline forearm rotation dynamometer, Fabrication enterprises Inc. Elmsford) and is compared with the opposite normal side. If the contralateral elbow is abnormal, reference values are used.[6] Measurements of forearm pronation and supination normal strength (matched to age and gender) with a mobile device have recently been published and are included into the LES file. The contralateral or reference pronation/supination strength values must be filled out. Pronation and supination strength data (kilograms) are then automatically converted into percentages and into the corresponding value among the 5 grades. Alternatively, the pronation and supination strength is recorded following the MRC system[7] according to the LES grading boxes.

The LES also displays the Subjective Elbow Value (SEV) which is equivalent to the subjective shoulder value and subjective wrist value (SWV), widespread used in shoulder and wrist surgery. The SEV is determined subjectively by each patient, answering the following question: "what is the overall percent value of your elbow if a complete normal elbow represents 100%?" In order not to overweight the subjective aspect of the LES, the SEV is not included into the LES calculations.

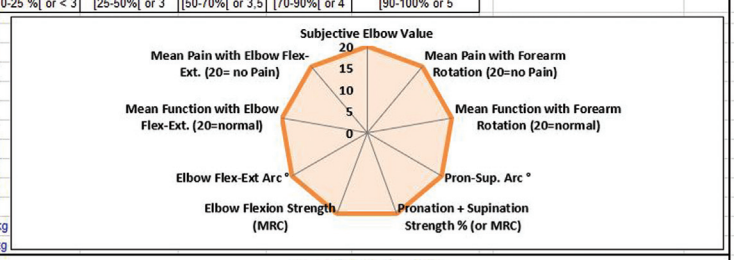
Lyon Elbow Clinical Evaluation Form V1.3

Patient's Name		Gender:		Age:		Date	Height:	Physician's Name	Weight:	
Occupation		Side		Dominance						
	Mean VAS Pain/10	0		Subjective Elbow Value %		100	Quick Dash	0		
			Grades	0	5	10	15	20=Normal	Summary	Mean
	Subjective Elbow Value		20	0-25 %[	[25-50%[	[50-70%[	[70-90%[	[90-100%	Mean VAS Pain /10	0
	Mean Pain with Elbow Flex-Ext. (20= no Pain)	None	20	At Sleep	At Rest	With Motion	Effort / Weather	None	SEV (%)	100
	Mean Pain with Forearm Rotation (20=no Pain)	None	20	At Sleep	At Rest	With Motion	Effort / Weather	None	Elbow Extension DEFICIT	0
	Mean Function with Elbow Flex-Ext. (20=normal)	Normal	20	Severe Loss	Important Loss	Moderate Loss	Minimal Loss	Normal	Elbow Flex./ Ext. Arc °	140
	Mean Function with Forearm Rotation (20=normal)	Normal	20	Severe Loss	Important Loss	Moderate Loss	Minimal Loss	Normal	Pron./Sup. Arc °	156
	Elbow Flex-Ext Arc °	140	20	0-40[	[40-70[	[70-100[	[100-130[	[130°	MRC Flex. Strength (%)	100
	Pron-Sup. Arc °	156	20	0-40[	[40-80[	[80-120[	[120-150[	[150°	MRC or Kg P/S Strength (%)	100
	Elbow Flexion Strength (MRC)	5,0	20	< 3	3	3,5	4	5	Lyon Elbow Score (%)	100
	Pronation + Supination Strength % (or MRC)	100	20	0-25 %[or < 3	[25-50%[or 3	[50-70%[or 3,5	[70-90%[or 4	[90-100% or 5		
			Contralateral*							
	Elbow Flexion (normal 143°)	140								
	Elbow Extension DEFICIT	0								
	Pronation (normal 75°)	75								
	Supination (normal 81°)	81								
	Elbow Flexion Strength (MRC)	5								
	*Pronation Strength kg ***	71	71							
	*Supination Strength kg ****	117	117							
	Pronation + Supination Strength kg	188	188							

** Normal Values if Contralateral Disorder*

** Normal pronation Strength: Male Dominant:71 kg /non dom. 60 kg - Female Dom. 46 kg /non dom. 40 kg

*** Normal Supin. Strength: Male Dominant 117 kg /non dom 100 kg - Female Dom. 77 kg /non dom. 70 kg



Lyon Elbow Score	**100**	**Excellent >90**

Fig. 1 Lyon Elbow score, filled out for a normal patient.

Forearm Score

Similarly, to the LES, our new computerized clinical forearm score (Lyon Forearm Score, LFS) includes four clinical criteria related to the forearm: pain, function, active range of motion, and muscle strength. The LFS file is built on the same fashion as the LES and LWS but addresses the elbow, forearm "joint" and the wrist so that humeroulnar, PRUJ, DRUJ, and radiocarpal/midcarpal joints could be evaluated. As for the Lyon Wrist Score and LES, the weight of each criterion (pain, function, active motion, and strength) is equivalent so that patient's and physician's related scores are equally balanced. The LFS provides a percentage value. The higher the percentage is, the better is the clinical result. The LFS form is displayed in ►**Fig. 2**.

The surgeon's assistant only needs to fill out the pink colored boxes (data boxes) in an excel file during patient's examination. Yellow calculations boxes, radar diagrams, and a yellow summary table are automatically generated.

Results

The computerized LES and LFS are automatically generated comprehensive Elbow and forearm scores.

Similar to the Lyon Wrist Score,[4] Mayo-modified wrist score[4] and Mayo Elbow performance score (MEPS),[8] four LES and LFS categories were arbitrarily defined as excellent (equal or superior to 90%), good (equal or superior to 70% and inferior to 90%), fair (equal or superior to 50% and inferior to 70%), and poor (inferior to 50%). This scoring system may be used for pre- and/or postoperative clinical evaluations.

The LES and LFS components are automatically included into diamond-shape graphs and tables which include the SEV and subjective forearm value (SFV) as well. Both diamond-shape graphs and tables are practical tools which can be directly exported into PowerPoint presentations for demonstration and comparison purposes.

In order not to overweight the subjective assessment part, SEV and SFV are not part of elbow and forearm scores calculations.

The LES and LFS charts are displayed in ►**Figs. 1** and **2**. Both LES and LFS are available for free download in colored versions at *alcoms69@lyon.fr*.

Discussion

The use of comprehensive clinical scores for the elbow and forearm is mandatory to compare their pre- and postoperative status and helps defining the usefulness of a surgical procedure or non-surgical treatment. Modern clinical scores should be computerized and updatable.

The authors present a computerized elbow clinical score (LES) used since 1999 in their unit. In addition, the authors present the first version of a new computerized forearm score (LFS) that may be used to evaluate forearm disorders such as the Essex-Lopresti injuries. These user-friendly updatable clinical elbow and forearm scores are based on four classic clinical criteria, pain, function, motion, and strength that are expressed into grades.

Current elbow clinical scores are scarce. Some of them are no longer used.[3] As far as we know, none of them are computerized yet.

The MEPS[8] is the most widely used. It has been described as a score with strong reliability.[9] However, it neither includes elbow flexion strength nor forearm rotation values. It gives a significant weight to elbow stability, which may not be relevant to all elbow disorders.

The ASES standardized elbow method[10] provides a comprehensive analysis but does not provide a score per se. The Oxford elbow score although rated as an excellent score[11] is a

Lyon Forearm Clinical Evaluation Form. V1.3

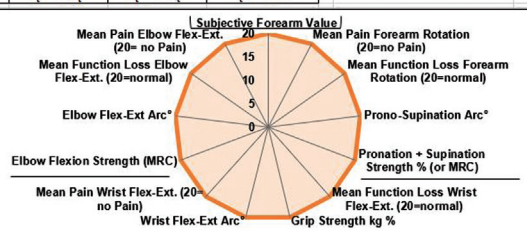
Patient's Name	Gender		Age		Date:	Physician's name :		
Occupation	Side		Dominance			Height		Weight
Mean VAS Pain /10	0		Subjective Forearm Value %		100	Quick Dash	0	

		Grades	0	5	10	15	20=Normal
Subjective Forearm Value		20	0-25 %[	[25-50%[	[50-70%[	[70-90%[	[90-100%
Mean Pain Elbow Flex-Ext. (20= no Pain)	None	20	At Sleep	At Rest	With Motion	Effort / Weather	None
Mean Pain Forearm Rotation (20=no Pain)	None	20	At Sleep	At Rest	With Motion	Effort / Weather	None
Mean Pain Wrist Flex-Ext. (20= no Pain)	None	20	At Sleep	At Rest	With Motion	Effort / Weather	None
Mean Function Loss Elbow Flex-Ext. (20=normal)	Normal	20	Severe Loss	Important Loss	Moderate Loss	Minimal Loss	Normal
Mean Function Loss Forearm Rotation (20=normal)	Normal	20	Severe Loss	Important Loss	Moderate Loss	Minimal Loss	Normal
Mean Function Loss Wrist Flex-Ext. (20=normal)	Normal	20	Severe Loss	Important Loss	Moderate Loss	Minimal Loss	Normal
Elbow Flex-Ext Arc°	140	20	0-40[	[40-70[	[70-100[	[100-130[	[130°
Prono-Supination Arc°	155	20	0-40[	[40-80[	[80-120[	[120-150[	[150°
Wrist Flex-Ext Arc°	155	20	0-30[	[30-75[	[75-110[	[110-150[	[150°
Elbow Flexion Strength (MRC)	5,0	20	< 3	3	3,5	4	5
Pronation + Supination Strength % (or MRC)	100	20	0-25 %[or < 3	[25-50%[or 3	[50-70%[or 3,5	[70-90%[or 4	[90-100% or 5
Grip Strength kg %	100	20	0-25 %[	[25-50%[	[50-70%[	[70-90%[	[90-100%

Summary	Mean
Mean VAS Pain /10	0
SFV (%)	100
Elbow Extension Deficit	0
Elbow Flex./Ext. Arc °	140
Pron./Sup. Arc °	155
Wrist Flex./Ext. Arc°	155
MRC Flex. Strength (%)	100
MRC or Kg P/S Strength (%)	100
Grip Strength (%)	100
Lyon Forearm Score (%)	100

		Contralateral*
Elbow Flexion (normal 143°)	140	
Elbow Extension Loss	0	
Pronation (normal 75°)	75	
Supination (normal 81°)	80	
Wrist Flexion (normal 75°)	80	
Wrist Extension (normal 75°)	75	
Elbow Flexion Strength (MRC)	5	
*Pronation Strength kg ***	71	71
*Supination Strength kg ****	117	117
Pronation + Supination Strength kg	188	188
*Grip Strength kg*****	48	48

** Normal Values if Contralateral Disorder*
*** Normal Pronation Strength: Male Dominant:71 kg /non dom. 60 kg - Female Dom. 46 kg /non dom. 40 kg*
**** Normal Supination Strength :- Male Dominant 117 kg / non dom. 100 kg - Female Dom. 77 kg /non dom. 70 kg*
*****Normal Grip Strength. Male Dominant 48 kg /non dom. 45 kg - Female Dominant 25 kg /non dom. 22 kg*



Lyon Forearm Score	100	Excellent >90

Fig. 2 Lyon Forearm score, filled out for a normal patient.

patient's related score that does not include elbow motion and strength measurements. Other patient's-related score were recently developed[12] but they do not include physician's assessment.

Regarding forearm evaluation, and to the best of our knowledge, no clinical score is available to evaluate all anatomical components of a forearm disorder such as the Essex-Lopresti injuries.

Both LES and LFS were built on the Lyon wrist score concept. These upper extremity scores are open, i.e., pain, function, range of motion, and muscle strength may be subdivided in more criteria if necessary. For example, average pain may be further refined into rest and exercise pain. Elbow strength may include elbow extension strength if specific evaluation of a triceps repair is requested. Elbow strength may be measured using a dynamometer instead of MRC values without changing the calculation system since the data are expressed in percentages.

Similarly to our recent published user friendly Lyon wrist score[4], LES and LFS allow a comprehensive standardized and computerized analysis of any disorders of the elbow, forearm, and wrist. LES, LFS, and LWS include both the patient self-evaluation part (pain, function) and an objective part filled out by the physician (active range of motion and strength). Any clinical preoperative or outcome scores should reflect the perspective of the patient and include the physician's-based motion and strength criteria. Such assessment should be independent of the diagnosis. It is the author's opinion that the weight ratio between patient's and physician's assessment should be 50/50. Therefore, the weight allocated to each part is equivalent in LES, LFS, and LWS.

A comprehensive assessment of patient's specific clinical status before and after treatment is a critical part of any osteoarticular clinical research. All the components of an evaluated given joint should be included. For example, a wrist joint score evaluating a distal radius malunion should include forearm rotation assessment. Therefore, we included into our wrist score, radiocarpal/midcarpal joints and DRUJ evaluation. Similarly, the LES includes humero-ulno-radial joint and PRUJ evaluation. The LFS provides a clinical assessment of all components of the forearm including the elbow and wrist.

Regarding patient's-related criteria, visual analog and visual rating evaluation of average pain is well accepted. The advantage of assessing function on a visual rating scale[5] is that it is tailored to patient's real-life activities and needs whether they are daily living, work, or sports-related activities.

Dynamometers measuring grip strength, so-called Jamar devices, are widely available in clinics. However, dynamometers measuring elbow flexion strength and pronation/supination strength may not be available in all clinical facilities. This is why measurement of elbow muscle strength in LES and LFS is performed manually using the MRC evaluation. Measurement of pronation/supination strength may be recorded either as comparative quantitative kilogram values or as MRC values. Because of the open nature of LES and LFS, these measurements may be modified in future versions of the scores.

SEV is a published criterion[13,14] which is included into the radar representation of the LES. However, the SEV is not part of calculation of LES in order not to overweigh the subjective evaluation. Similarly, a new SFV was presented in this paper, using the same concept. As the SEV and SWV, the SFV is included into the graphical display of LFS but is not part of the LFS calculation.

This paper has weaknesses since the LES and LFS have been used only in our unit yet. The physician's-related parts of LES and LFS require an assistant while the surgeon examines the patient. More than thousand LES have been filled out so far whereas the LFS is a new score. Neither LES nor LFS has been validated per se so far, but both represent a combination of simple and well-accepted criteria. Inter and intraobserver studies should be performed in the future.

There are several strengths in these two new upper extremity scores, as to know:

The LES and LFS charts are user-friendly. They are easily and quickly filled out by an assistant during the surgeon's examination. As far as we know, they are the first computerized elbow and forearm scores including automated calculations and generating instant diamond-shaped graphs and summary tables. The graphic representation of both LES and LFS displays an unprecedented comprehensive representation of elbow and forearm clinical status. The radar graphs and summary tables can be exported directly into PowerPoint presentations for research and presentation/comparisons purposes.

LES and LFS scores were designed to evaluate any osteoarticular elbow or forearm disorder regardless of the etiology. The LFS is the first clinical score that can clinically evaluate forearm disorders as the Essex Lopresti or outcomes of surgical treatments.

Conflicts of Interest

None declared.

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