Physical Behavior and Function Early After Hip Fracture Surgery in Patients Receiving Comprehensive Geriatric Care or Orthopedic Care—A Randomized Controlled Trial

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Background. This study is a part of the randomized controlled trial, the Trondheim Hip Fracture Trial, and it compared physical behavior and function during the first postoperative days for hip fracture patients managed with comprehensive geriatric care (CGC) with those managed with orthopedic care (OC).

Methods. Treatment comprised CGC with particular focus on mobilization, or OC. A total of 397 hip fracture patients, age 70 years or older, home dwelling, and able to walk 10 m before the fracture, were included. Primary outcome was measurement of upright time (standing and walking) recorded for 24 hours the fourth day postsurgery by a body-worn accelerometer-based activity monitor. Secondary outcomes were number of upright events on Day 4, need for assistance in ambulation measured by the Cumulated Ambulation score on Days 1–3, and lower limb function measured by the Short Physical Performance Battery on Day 5 postsurgery.

Results. A total of 317 (CGC n = 175, OC n = 142) participants wore the activity monitor for a 24-hour period. CGC participants had significantly more upright time (mean 57.6 vs 45.1 min, p = .016), higher number of upright events (p = .005) and better Short Physical Performance Battery scores (p = .002), than the OC participants. Cumulated Ambulation score did not differ between groups (p = .234).

Conclusions. When treated with CGC, compared with OC, older persons suffering a hip fracture spent more time in upright, had more upright events, and had better lower limb function early after surgery despite no difference in their need for assistance during ambulation.

Key Words: Geriatric assessment—Hip fracture—Physical activity.

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IMMOBILIZATION and bed rest in older persons admitted to hospital is known to lead to decreased activity and functional level (1). In patients immobilized longer than 2 days after hip fracture surgery, functional recovery and discharge from hospital is delayed (2). In contrast, early ambulation after hip fracture surgery has been found to improve short-term postoperative outcomes (3–5). Early mobilization regimes are therefore highly recommended after hip fracture surgery (6–8). However, few studies have objectively assessed how active patients are early after hip fracture surgery. After hip fracture surgery, most patients need assistance in getting out of a bed and a chair, and for standing and walking. The level of assistance required appears to be important for short-term outcomes such as length of hospitalization, time to discharge, mortality, and medical complications (5). The reason for this may be that patients who require more assistance ambulate less. A recent study showed that older patients spent more time being upright if they were independent in mobility (9). The largest portion of time in upright for in-hospital patients seems to be in the morning hours (0800–1200 h) (10). This is likely because
most ambulation occurs in situations where the nursing staff is assisting patients in carrying out self-care activities such as walking to the shower or walking to the dining room (10). The amount of available assistance, staff initiatives, and interdisciplinary efforts on assessment and treatment throughout the day may therefore have an important impact on the amount of daily ambulation a patient is able to achieve and may thus also affect rate of recovery.

Interdisciplinary treatment such as comprehensive geriatric assessment has been shown to be beneficial for acutely sick frail older persons (11,12). Hip fracture patients are often characterized by old age and frailty and are therefore likely to benefit from similar approaches during their hospital management (13,14). Treatment models for older hip fracture patients often include some kind of geriatric intervention (15–17) although these models differ in how, where, and when they are delivered.

Physical behavior, defined as patterns of daily physical activity, includes early mobilization and weight-bearing activities and is proposed as an important element of interdisciplinary treatment approaches (18). Currently, it is unknown whether interdisciplinary assessment and treatment approaches for hip fracture patients early after a fracture can improve physical behavior and thereby affect functional outcomes for a time after the hip fracture.

This study is a part of the Trondheim Hip Fracture Trial (REK 4.2008.335 and ClinicalTrials.gov, NCT00667914) (13,18). In this study, hip fracture patients were randomized in the emergency room to receive presurgery and early postsurgery treatment in either a geriatric or an orthopedic ward at St. Olavs Hospital, Trondheim University Hospital, Norway. In order to understand the role of early mobilization for functional outcomes 4 and 12 months after the fracture, the effect of treatment on mobilization was assessed during the hospital stay. The aim of this study was to assess if daily physical behavior as indicated by time spent in upright positions (standing and walking) the fourth day after surgery differed between hip fracture patients treated in a geriatric ward receiving comprehensive geriatric assessment compared with hip fracture patients receiving conventional treatment in an orthopedic ward. Because previous studies have shown significant benefits of comprehensive geriatric assessment, and hip fracture often occur in otherwise typical geriatric patients, we hypothesized that comprehensive geriatric care (CGC) also would result in increased time spent in upright position compared with orthopedic care (OC). We also aimed to assess differences in number of upright events during the day and physical function in terms of need for help during ambulation and lower limb functions.

METHODS

Study Design

The study is a randomized controlled trial, assessing intermediate outcomes of being treated with CGC or OC. Participants

Participants

Participants included in the Trondheim Hip Fracture Trial were admitted to hospital because of a hip fracture, and they had to be at least 70 years of age, previously living in their own homes, able to walk 10 m, and able to give informed consent. Patients with pathological fractures, multitrauma injuries, or short life expectancy were excluded. Further details about eligibility criteria for participants are described elsewhere (13). Participants were included from April 2008 to December 2010.

Interventions

CGC was performed by an interdisciplinary team of specialized health professionals developing and executing an integrated treatment plan for hip fracture patients. The treatment included interdisciplinary assessment of health, function, disease, and social situation and regular interdisciplinary meetings. The assessment and treatment had a particular focus on comorbidity, pain relief, hydration, oxygenation, nutrition, elimination, delirium, and early mobilization. A systematic approach including use of checklists and predescribed treatment protocols, mobilization regimes, and early discharge planning was used (18). The mobilization plan was carried out in collaboration between the physiotherapist and nursing staff at the department and was based on the following principles: (a) If there were no contraindications, patients were assisted during mobilization as early as the first postoperative day. (b) Progression according to the individual’s ability and progress was seen as an essential element. (c) Weight bearing was emphasized. (d) Short-term goals in individual rehabilitation plans were based on participants’ prefracture function.

The day after surgery, the physiotherapist and the nurse mobilized the patient together. Based upon observation during this mobilization, prefracture functional status, and type of surgery, a procedure was made for the mobilization and expected progress for each individual patient. This procedure was integrated with care plans (18). The physiotherapists had particular emphasis patients who did not manage to progress as expected. Both physiotherapists and nurses assessed pain by using a Verbal Ration scale (19) at rest and during mobilization to optimize pain treatment. OC participants received conventional care including traditional in-hospital physiotherapy (13).

The comprehensive geriatric assessment was delivered in a geriatric ward somewhat better staffed per patient bed, in terms of nurses/assistance nurses (1.67 vs 1.48), doctors (0.13 vs 0.11/0.08), physiotherapists (0.13 vs 0.09/0.07), and occupational therapists (0.13 vs 0), compared with the OC delivered in the orthopedic ward. Further details of the assessment and treatment of participants and staffing in the two treatment arms are described in two separate articles (13,18).
Demographic Data

Prefracture function was assessed retrospectively using the Nottingham Extended Activities of Daily Living scale (0–66) (20) and the Barthel Index (0–20) (21). Other demographic variables included age, gender, and fracture type (intracapsular or extracapsular). Intracapsular fractures were further classified into groups based on surgery method (arthroplasty or osteosynthesis).

Outcomes

Physical behavior was assessed by commercially available, small, body-worn, single-axis accelerometer-based activity monitors (activPAL, PAL Technologies Ltd., Glasgow, United Kingdom). The activity monitors were attached to the front of the participants’ nonaffected lower thigh with a waterproof tape on the third day postsurgery and removed on Day 5, and 24 hours of data, the fourth day postsurgery, were used for deriving activity outcomes. The outcomes derived from this activity monitor have been validated on a population of older persons with impaired mobility (22), showing perfect accuracy in upright time and upright events. The ActivPAL software gives the number and duration of upright (standing and walking) events. In this study, we used upright time defined as the total time spent in upright (primary outcome) and the number of upright events (secondary outcome) during 24 hours as outcomes for physical behavior.

Other secondary outcomes the Cumulated Ambulation score (CAS) (5) assessed over the first 3 days postsurgery, and the Short Physical Performance Battery (SPPB) (23,24) on Day 5 postsurgery. CAS evaluates the need for assistance during three mobilization tasks (transfer from lay-to-sit-to-lay, transfer from sit-to-stand-to-sit, walking with appropriate walking aid) and was scored by the ward physiotherapists or nurses in the geriatric ward and ward nurses in the orthopedic ward, providing scores (0 = unable to perform despite assistance, 1 = only able with assistance, 2 = able to perform independently) for each of the three tasks and a summary score for each of the first 3 postsurgery days. The total score ranges from 0 to 18, where 18 indicates independence in ambulation during all 3 days. The SPPB assesses lower limb function and consists of a balance task, a chair-stand task repeated five times, and a 4-m gait task. Each task is scored on a scale ranging from 0 to 4, with a summary score ranging from 0 to 12, where 12 is the best score. The SPPB was performed by the same study assessors for the two treatment groups and was assessed immediately after removing the activity monitor in order not to include activity while performing the SPPB in the activity monitoring results.

Sample Size

Sample size calculation was performed for the primary outcome in the Trondheim Hip Fracture Trial, which was lower limb function as measured by SPPB 4 months after hip fracture (13). All available participants were asked to wear activity monitors, and participants with complete 24 hours of activity monitoring at Day 4 after the hip fracture were included in the analyses.

Randomization

Randomization to either CGC or OC was performed with a web-based computer program developed by the Unit of Applied Clinical Research, Norwegian University of Science and Technology. Randomization was performed in the Emergency Department by block randomization with equal block sizes.

Blinding

Blinding was not possible for staff that provided the intervention, study participants, or assessors during the hospital stay. However, the data analysis was performed blinded to group allocation.

Data Analysis and Statistical Methods

Number and duration of upright events were derived from the ActivPAL data using the manufacturer’s Excel spreadsheets from software version 6.0.8 (activPAL, PAL Technologies Ltd.) and a custom made MATLAB (MATLAB version 7.1. The MathWorks Inc., Natick, MA, 2005) program to write an Excel spreadsheet (Office Excel version 11.0, Windows XP Professional, Microsoft, 2003) with outcome values for all participants.

Statistical analyses were performed using SPSS Inc. (SPSS Statistics for Windows, Version 19.0. Chicago: SPSS Inc.). The demographic details for participants who did not complete the activity monitoring (n = 80) were compared with those who did complete the activity monitoring (n = 317), using bivariate statistics (Mann–Whitney U tests, t tests and chi-square). Normality distribution was checked by visual inspection of Q–Q plots. Upright time, upright events, and SPPB were skewly distributed. To obtain normality, transformation by use of the natural logarithm of upright time (after adding five to avoid taking the logarithm of zero) and SPPB (after adding one for the same reason), and the square root of events, as suggested by Tabachnick and Fidell (25), were used. Differences between the two groups were assessed by use of linear regression, and adjustments for gender and fracture type were included in the final analyses.

Ancillary analyses of the differences between the two treatment arms in mean upright time during night (00:00–06:00), day (06:00–12:00), afternoon (12:00–18:00), and evening (18:00–24:00) were analyzed by use of the same transformation methods. Differences in upright time over the day are presented in a figure showing median upright time for each hour over the day (00:00–01:00, 01:00–02:00, etc).
RESULTS

Participant Flow
A total of 397 participants were randomized, of whom 361 wore activity monitors over 24 hours. Data were lost for 44 of the participants wearing an activity monitor. The flow diagram (Figure 1) presents the reasons for missing data. A total of 317 participants had 24 hours of monitoring data the fourth day after the hip fracture surgery and were included in the final analyses. Of these, three participants were discharged from the hospital during the monitoring hours.

The 317 participants completing the 24 hours activity monitoring had significantly higher prefracture scores on the Nottingham Extended Activities of Daily Living scale (median 47 vs 40, \( p = .020 \)) and Barthel Index (median 20 vs 19, \( p = .037 \)) compared with the 80 participants with no or noncomplete activity-monitoring data. A higher number of OC participants (\( n = 58 \)) compared with CGC participants (\( n = 22 \)) did not complete the monitoring. The portion of women and intracapsular fractures in the two groups of dropouts were not statistically different, even if there was a tendency toward more women in the CGC group of dropouts (90.9% vs 72.4%, \( p = .077 \)).

Baseline Data
Participants mean age was 83.1 (range 70–97) years, and their characteristics are presented in Table 1. Although the number of included participants in the two groups was different, there were no significant differences in age (mean 83.1 vs 83.0 y, \( p = .933 \)), gender (71.4 vs 78.2% women, \( p = .171 \)), Nottingham Extended Activities of Daily Living scale (median score 46.0 vs 47.5, \( p = .827 \)), or Barthel Index (median score 20 vs 20, \( p = .442 \)) between groups.

Outcomes and Estimation
After adjustments for gender and fracture type, CGC participants had significantly more time in upright position (mean 57.6 vs 45.1 min, \( p = .016 \)) and higher number of
upright events \((p = .005)\) than OC participants. Need for help during ambulation measured by CAS during the 3 first postoperative days did not differ significantly between groups \((p = .234)\). All participants performing SPPB on the fifth postoperative day used walking aids. CGC participants has better SPPB scores than OC participants \((p = .002)\). Details on results are shown in Table 2.

### Ancillary Analyses

CGC participants spent significantly more time than OC participants in upright position during the daytime (20.0 vs 15.4 min, \(p = .007\)) and in the afternoon (19.3 vs 14.4 min, \(p = .007\)). Median upright time for each hour during all 24 hours during the day for both groups are shown in Figure 2. Ninety-nine participants in the CGC and 69 in the OC spent more than 30 minutes in upright on this specific day. The maximum registered length of an upright event was 1 hour and 36 minutes. Eleven participants (four CGC, seven OC) were not in upright position at all during the day of the activity monitoring, whereas 19 (9 CGC, 10 OC) spent less than 5 minutes, 29 (14 CGC, 15 OC) spent less than 10 minutes, and 90 (49 CGC, 41 OC) participants spent less than 30 minutes in upright.

### Adverse Event Management

CGC and OC treatment were offered in parallel, where surgery and follow-up of new incidences including adverse events after discharge were offered for both groups by the orthopedics and the primary health care system as standard routine. Mortality rate in the CGC and OC was, however, monitored specifically by group, without any significant differences between the two wards, and the trial was carried out as planned according to the protocol (13).

### DISCUSSION

This study assessed objectively measured physical behavior of hip fracture patients during 24 hours in a trial comparing the potential benefits of CGC performed in a geriatric ward with OC in an orthopedic ward. We found that participants treated with CGC spent more time in upright position and had a higher number of upright events the fourth postoperative day. No differences were found between the two groups when measuring the first 3 days in participants’ need for assistance during ambulation by the use of CAS. For lower limb function as measured by the SPPB, the CGC participants had better lower limb function on the fifth day after surgery.

In this article we have highlighted ambulation and weight-bearing activities as important for the early treatment after surgery. It is important to underline that the positive results shown for the CGC group also reflect the total effect of the intervention program (18). Together, this could have ensured a more optimal approach than provided with standard treatment and may have made the patients able to spend more time in upright position. The difference of 12.5

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### Table 1. Participant Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Total sample, (n = 317)</th>
<th>Intervention, (n = 175)</th>
<th>Controls, (n = 142)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, y, ((SD))</td>
<td>83.1 (6.0)</td>
<td>83.1 (5.8)</td>
<td>83.0 (6.3)</td>
</tr>
<tr>
<td>Female gender (%)</td>
<td>74.4</td>
<td>71.4</td>
<td>78.2</td>
</tr>
<tr>
<td>Intracapsular fracture (%)</td>
<td>60</td>
<td>58</td>
<td>63</td>
</tr>
<tr>
<td>Intracapsular with arthroplasty (%)</td>
<td>65</td>
<td>64</td>
<td>65</td>
</tr>
<tr>
<td>Median Barthel Index (IQR)</td>
<td>20 (17–20)</td>
<td>20 (17–20)</td>
<td>20 (18–20)</td>
</tr>
<tr>
<td>Median NEADL (IQR)</td>
<td>47 (30.0–58.0)</td>
<td>46 (28.8–58.0)</td>
<td>47.5 (33.3–57.8)</td>
</tr>
</tbody>
</table>

Notes: NEADL = Nottingham Extended Activities of Daily Living scale, IQR = the interquartile range. Barthel Index was performed for 299 of the 317 participants and NEADL for 314 out of 317.

### Table 2. Measures of Physical Behavior and Physical Function Early After Hip Fracture

<table>
<thead>
<tr>
<th></th>
<th>Total sample</th>
<th>CGC</th>
<th>OC</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ((SD))</td>
<td>Mean ((SD))</td>
<td>Mean ((SD))</td>
<td>CGC–OC (adjusted (p)-value)</td>
</tr>
<tr>
<td>Upright</td>
<td>52.0 (63.7)</td>
<td>57.6 (67.9)</td>
<td>45.1 (57.7)</td>
<td>12.5 (.016)</td>
</tr>
<tr>
<td>Events</td>
<td>21.8 (19.9)</td>
<td>24.1 (22.1)</td>
<td>19.0 (16.5)</td>
<td>5.1 (.005)</td>
</tr>
<tr>
<td>CAS</td>
<td>9.7 (3.8)</td>
<td>9.9 (3.9)</td>
<td>9.4 (3.8)</td>
<td>0.5 (.234)</td>
</tr>
<tr>
<td>SPPB</td>
<td>1.4 (1.8)</td>
<td>1.6 (2.0)</td>
<td>1.0 (1.6)</td>
<td>0.6 (.002)</td>
</tr>
<tr>
<td>Upright time during the 24-h period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Night</td>
<td>3.3 (7.2)</td>
<td>3.1 (6.4)</td>
<td>3.6 (8.1)</td>
<td>0.5 (.704)</td>
</tr>
<tr>
<td>Day</td>
<td>18.0 (23.9)</td>
<td>20.0 (24.5)</td>
<td>15.4 (22.9)</td>
<td>4.6 (.007)</td>
</tr>
<tr>
<td>Afternoon</td>
<td>17.1 (23.6)</td>
<td>19.3 (25.8)</td>
<td>14.4 (20.4)</td>
<td>4.9 (.007)</td>
</tr>
<tr>
<td>Evening</td>
<td>13.6 (17.6)</td>
<td>15.0 (19.6)</td>
<td>11.8 (14.8)</td>
<td>3.2 (.053)</td>
</tr>
</tbody>
</table>

Notes: Upright = time in upright position (min); events = number of upright events; CAS = Cumulated Ambulation score; SPPB = Short Physical Performance Battery score; CGC = comprehensive geriatric care; OC = orthopedic care. CAS was performed by 299 of the 317 participants and SPPB for 295 out of 317.
minutes in upright time between groups constitutes 24% of total time in upright for the sample in this study, which might represent an important clinical difference in this very inactive sample. If so, it is suggested that the approach developed and executed for hip fracture patients in a geriatric ward with focus on mobilization can provide results that are beneficial for patients’ physical behavior later in the trajectory after hip fracture. However, further studies are needed to conclude on thresholds for clinically meaningful differences of upright time in inactive samples.

CGC participants spent significantly more time in an upright position during daytime and afternoon. The patterns shown in Figure 2 suggest that for OC participants, most of the upright time happened between 8 and 9 AM, when patients performed important morning activities, compared with the CGC participants who also spent time in an upright position during other hours of the day. The difference in physical behavior between groups was likely not because the OC participants needed more help during ambulation as we found no difference in CAS scores between the two groups. It is likely that the interdisciplinary approach and the mobilization included in the care plans increased the number of times and the total time the CGC patients were mobilized. The spread in upright time throughout the day in the CGC participants suggests that the staff at the geriatric ward integrated mobilization with other activities like dining and visits to the toilet.

The participants in this study were old, most of them were women, they spent very little time in an upright position, they had a low number of upright events, and their most upright time occurred during day and afternoon. However, there was a great variation in upright time and upright events between participants, indicating a heterogeneous sample of older hip fracture patients in terms of physical behavior. Our findings were similar to other studies measuring physical behavior in hospital settings, such as a study on 50 upper abdominal surgery patients with mean age of 61 years reporting 34.4 minutes as median time in upright the fourth postoperative day (10). Another study showed that older inpatients with a mean age of 81 years, with different medical diagnoses, had less than 1.5 hours per day in upright time, ranging from 2 minutes to almost 4 hours (26). Physical activity during a typical inpatient stay seems to be low on average and with large between-patients variations. Any hospital treatment especially in older patients should therefore be tailored and delivered focusing on individual needs, such as a CGC program with particular focus on mobilization.

For our older hip fracture patients with impaired function already before the fracture, immobilization, or very low levels of physical behavior after the surgery would represent an extra risk of further functional loss, thereby additionally reducing the chance of independent walking and independence in daily life activities. Although the treatment groups did not differ in their prefracture functional levels, physical behavior after the surgery did differ, indicating that upright time and upright events can be affected and should therefore be more at focus early after hip fracture surgery. Our findings indicate that hospital staff, working with older hip fracture patients in wards can affect the amount of time
patients spend in an upright position by focusing more systematically on routines for early mobilization. This is also supported in a previous study evaluating reasons for how nurses decide to ambulate older patients (27), where the authors highlight the complex nature of mobilization as a decisive factor. The patient focus in treatment models for older persons should probably be planned and carried out as a “care with” focus compared with a more passive “care for” focus, as described by Resnick and coworkers (28).

Our results demonstrate how little time the participants spend in an upright position and how few upright events are performed early after hip fracture. Activity monitoring data collected later in the rehabilitation phase can provide information about physical behavior when the medical status is more stable. In the study from Resnick and colleagues (29) participants spent only 70.4 minutes per day in all types of physical activities 2 months after hip fracture. The difference between CGC and OC in our study needs to be evaluated in later phases of the rehabilitation in future studies.

Upright time is a potentially important outcome of physical behavior in this population although it cannot distinguish between intensity of performed activities. Both low- and high-functional capacity groups of older persons spend most time in ambulatory activities at lower intensities (30), and little or no time is spent in high-intensity activities (29,30). The overall activity level is low in hip fracture patients, and total time in an upright position will capture most activities. The activity monitor used in this study did not distinguish between sitting and lying although time in sitting could be an important mobilization goal for some patients, especially because the total time in upright position was very low. Nevertheless, ambulation and time in upright position should be the main focus when aiming at regaining gait function.

A shortcoming with this study was higher number of dropouts in the OC, compared with the CGC group. The different reasons for this are reported in the flowchart (Figure 1). The dropouts had lower scores on prefracture function, indicating that data were not missing at random. The fact that the dropouts had lower scores than the included further strengthens the findings of better results in the CGC compared with the OC group.

The study used wide inclusion criteria, thus strengthening the external validity of the study. Several factors strengthen the findings of differences in upright time between groups: There were no group differences in prefracture function. Furthermore, group differences did not change after controlling for gender and fracture type. Finally, the group differences in favor of the CGC were also confirmed for the other outcomes except for the CAS.

The staffs at both wards were aware of the activity monitoring, and it is thus possible that this might have given an extra motivation to mobilize the patients. However, the staff at both wards received the same information about the activity monitoring, and it is thus likely that the bias is the same in both groups. Assessors performing the SPPB were not part of the staffs at the two wards but were, however, a part of the research group performing the study. To our best knowledge, we do not believe this has affected the test results for the two groups.

The study is part of the Trondheim Hip Fracture Trial that primarily aims to assess the effects of CGC on mobility 4 months after a hip fracture. A limitation for this study is that the aims were not specified in the protocol paper or in the ClinicalTrials.gov document. The results from this study may, however, be important for understanding possible differences in mobility between groups 4 and 12 months after the fracture.

**Conclusion**

Although older persons show great variation in physical behavior after hip fracture, a typical older person spends little time being upright the fourth postoperative day. This study showed that upright time and upright events, as well as lower limb function, can be modified if it is part of a planned and individually delivered comprehensive geriatric care in a geriatric hospital ward with particular focus on mobilization. The implications for regaining of function and physical behavior later in the rehabilitation should be further evaluated.

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**Conflict of Interest**

One of the authors is a co-inventor of the activPAL physical activity monitor and a director of PAL Technologies Ltd.

**References**