Although more widespread screening and routine adjuvant therapy has improved the outcome for breast cancer patients in recent years, there remains considerable scope for improving the efficacy, safety and tolerability of adjuvant therapy in the early stage disease and the treatment of advanced disease. Toremifene is a selective estrogen receptor modifier (SERM) that has been widely used for decades in hormone receptor positive breast cancer both in early and late stage disease. Its efficacy has been well established in nine prospective randomized phase III trials compared to tamoxifen involving more than 5500 patients, as well as in several large uncontrolled and non-randomized studies. Although most studies show therapeutic equivalence between the two SERMs, some show an advantage for toremifene. Several meta-analyses have also confirmed that the efficacy of toremifene is at least as good as that of tamoxifen. In terms of safety and tolerability toremifene is broadly similar to tamoxifen although there is some evidence that toremifene is less likely to cause uterine neoplasms, serious vascular adverse events and it has a more positive effect on serum lipids than does tamoxifen. Toremifene is therefore effective and safe in the treatment of breast cancer. It provides not only a useful therapeutic alternative to tamoxifen, but may bring specific benefits.

Mustonen MVJ, Pyrhönen S, Kellokumpu-Lehtinen PL. Toremifene in the treatment of breast cancer. World J Clin Oncol 2014; 5(3): 393-405 Available from: URL: http://www.wjgnet.com/2218-4333/full/v5/i3/393.htm DOI: http://dx.doi.org/10.5306/wjco.v5.i3.393

INTRODUCTION

Despite improvements in screening and treatment, breast cancer remains a significant cause of morbidity and mortality; accounting for almost one-third of all cancer diagnoses in the US and is second only to lung cancer as a cause of cancer mortality[1]. Over a million women are diagnosed each year worldwide and almost half a million deaths due to breast cancer are recorded each year[2]. Whilst incidence rates are considerably higher in developed than in developing countries, survival rates are low in developing countries, probably due to the lack
of screening and systematic use of adjuvant therapy. Historically low rates of breast cancer in, for example, the Eastern World have shown a rapid increase in recent years. Although typically a disease of later life, breast cancer among younger, pre-menopausal women appears to be more common than in the Western World. Breast cancer among young women, although comprising only around 7% of diagnosed cases, is associated with later presentation, high grade tumors, hormone receptor negativity and human epidermal growth factor receptor 2 (HER2) overexpression; factors that lead to a poorer overall prognosis.

The place of estrogen receptor modifiers (SERMs) in the treatment of breast cancer is now well established. Survival in breast cancer patients in the developed world has increased considerably over the past several decades, due principally to more widespread screening and the systematic use of adjuvant therapy. Whilst adjuvant therapy with SERMs, aromatase inhibitors, cytotoxic agents, monoclonal antibodies and other agents has transformed the outlook for breast cancer patients, there remains considerable unmet need for improvements in both efficacy and tolerability.

Toremifene
The first SERM to be introduced, tamoxifen, provided a revolutionary new treatment option for patients with hormone receptor positive breast cancer. With more than 30 years of experience now available this treatment modality has shown itself to be effective and physicians have learned how to manage its side effects. The mixed agonist/antagonist properties of SERMs define both their therapeutic effects and their undesirable effects. The different structural properties of different SERMs appear to influence their oncogenicity in both laboratory and clinical studies.

The structure of toremifene differs from that of tamoxifen in that a chlorine atom replaces one of the hydrogen atoms in the ethyl side chain. This difference may modify the metabolism of toremifene such that the production of DNA adducts may be prevented or reduced compared with tamoxifen.

Almost 25 years have elapsed since the first marketing authorization of toremifene and during that time considerable clinical experience has accumulated indicating its efficacy, safety and good tolerability. Indeed, so good was the safety and tolerability that the initially registered dose (60 mg per day) has been widely increased to 240 mg per day.

Toremifene dosage
As shown in Tables 1 and 2 a variety of doses of toremifene are, or have been, in common use. Although some early dose finding studies failed to distinguish between a wide range of doses from 20 mg to 200 mg, 60 mg was chosen as the most appropriate balance between anti-estrogenic effects and tolerability in Phase II studies; significant side effects being observed at the highest doses tested (680 mg). Dose finding and other studies suggested that 60 mg was safe and effective in breast cancer and more effective than 20 mg. However, extrapolation from animal studies suggested that even higher doses would be well tolerated; phase I studies showed that 460 mg daily for five consecutive days was the highest fully tolerated dose. A conservative approach led to 240 mg being chosen for the high dose formulation. Subsequent phase III clinical trials appear to bear out the enhanced efficacy of the higher dose formulations of toremifene.

Randomized studies with toremifene
There have been ten randomized controlled studies comparing toremifene with tamoxifen. Collectively, these studies, which include a total of more than 5500 patients show rather clearly that toremifene is not less effective than tamoxifen. These studies are summarized in Table 1.

Toremifene in advanced breast cancer
An early double-blind, Japanese study in 114 women with advanced or recurrent breast cancer found toremifene 40 mg and tamoxifen 20 mg resulted in similar response rates (26.3% vs 28.1%) and duration of response (155.0 vs 154.5 d). However, the time to onset of complete response was significantly shorter with toremifene than with tamoxifen (91 vs 169 d; P < 0.05).

A Nordic study compared toremifene 60 mg with tamoxifen 40 mg in 415 postmenopausal women with advanced breast cancer in a double-blind randomized manner. Response rates were similar in toremifene and tamoxifen groups (31.5% vs 37.3%). Time to treatment failure and median overall survival were also similar.

An open study conducted in Eastern Europe compared toremifene 60 and 240 mg, with tamoxifen 40 mg in 463 postmenopausal women with advanced breast cancer. Response rates of 20.4% and 20.8% were achieved with toremifene 60 mg and tamoxifen, respectively. Although the response rate with the higher dose of toremifene was slightly higher (28.7%), it did not differ significantly from the other treatments. The findings were similar for time to progression and overall survival, quality of life, as assessed by changes in the Eastern Cooperative Oncology Group (ECOG) scale, was better with toremifene 60 mg than with tamoxifen.

A four-way randomized study was undertaken in 541 women in Russia comparing two doses of toremifene (60 mg and 240 mg) with tamoxifen (20 mg) and letrozole (2.5 mg). Objective responses were most frequent in the toremifene 240 mg group (41.5%); objective responses were lower (though not statistically significantly so) in the toremifene 60 mg and letrozole groups (33.0% and 35.4% respectively). The proportion of responses in the tamoxifen group was statistically significantly lower than in the other three treatment groups. Similarly, the median duration of remission was longest in the toremifene 240 mg group (14.5 mo), shortest in the tamoxifen group (9.2 mo) and intermediate in the toremifene 60 mg and
| Ref.                  | Type | Pts Description                  | Diagnosis                          | Receptor status | Follow-up | Treatment       | Results |
|----------------------|------|----------------------------------|------------------------------------|-----------------|-----------|-----------------|---------|
| Nomura et al[39], 1993 | DB   | 114 women                        | Advanced or recurrent breast cancer | NS              | NS        | TOR 40 mg / TAM 20 mg | RR 26.3% / 28.1% / 169 d (P < 0.05), Time to onset of CR TOR 40 mg / TAM 20 mg / Duration of efficacy 155 d |
| Hayes et al[29], 1995 | OL   | 648 post or peri-menopausal women | Metastatic breast cancer           | Positive or unknown | NS        | TOR 60 mg / TAM 20 mg | Overall RR TOR 60 mg / TAM 20 mg / Duration of efficacy: 50% / 48% / 21% / 23% / 44% (ns) / 19% (ns) |
| Gershanovich et al[31], 1997 | OL   | 463 post-menopausal women        | Advanced breast cancer             | Positive or unknown | Median 20.5 mo | TOR 60 mg / TAM 20 mg | Overall RR TOR 60 mg / TAM 20 mg / Duration of efficacy: 20.4% / 28.7% / 20.8% |
| Pyrhönen et al[32], 1997 | DB   | 415 post-menopausal women        | Advanced breast cancer             | Negative or unknown | Median 20.5 mo | TOR 60 mg / TAM 20 mg | Overall RR TOR 60 mg / TAM 20 mg / Duration of efficacy: 31.3% / 37.3% |
| Holli et al[33], 2000 | OL   | 899 post-menopausal women        | Early invasive breast cancer       | Any              | Median 3.4 yr | TOR 60 mg / TAM 20 mg | Overall RR TOR 60 mg / TAM 20 mg / Duration of efficacy: 21.6 mo / 23.5 mo |
| Milla-Santos et al[34], 2001 | DB   | 217 women                        | Advanced breast cancer             | Positive         | NS        | TOR 40 mg / TAM 20 mg | Overall RR TOR 40 mg / TAM 20 mg / Duration of efficacy: 21.3% / 26.1% / 23.1% / 24.3% / 19.6 |
| Pagani et al[35], 2004 | OL   | 1035 peri or post-menopausal women | Lymph node positive breast cancer | ER positive      | Median 5.5 yr | TOR 60 mg / TAM 40 mg | Overall RR TOR 60 mg / TAM 40 mg / Duration of efficacy: 5.2% / 25% |
| Zejnalov et al[30], 2006 | OL   | 541 post-menopausal women        | Disseminated breast cancer         | Positive         | NS        | TOR 40 mg / TAM 20 mg | Overall RR TOR 40 mg / TAM 20 mg / Duration of efficacy: 41.3% / 26.7% / 33% (ns) / Median survival: 11.9 mo |
| Lewis et al[36], 2010 | OL   | 1813 peri or post-menopausal women | Early primary invasive breast cancer | Positive or unknown | Median 59 mo | TOR 60 mg / TAM 20 mg | Overall RR TOR 60 mg / TAM 20 mg / Duration of remission: 25.6% / 33% / 33% / 35.4% / 5-Yr DFS: 91.2% / 91.2% |
| Kimura et al[37], 2012 | OL   | 253 post-menopausal women        | Early phase breast cancer          | Positive or unknown | Median 66.5 mo | TOR 40 mg / TAM 20 mg | Overall RR TOR 40 mg / TAM 20 mg / 5-Yr survival: 97% / 96.7% / 97.5% / 97.3% / OS: 90.6% |
| Yamamoto et al[38], 2013 | OL   | 91 post-menopausal women         | Advanced, Non-steroidal aromatase inhibitor resistant in metastatic breast cancer | Positive         | Median 16.9 mo | TOR 120 mg / Exemestane 25 mg | Overall RR TOR 120 mg / Exemestane 25 mg / Duration of remission: 16.9 mo / 26.7% (ns) / (P<0.045) |

DB: double blind; CR: complete response; PR: partial response; SD: stable disease; LSD: long stable disease; TOR: Toremifene; TAM: Tamoxifen; DFS: disease-free survival; OS: overall survival; (O)RR: objective response rate; CB: clinical benefit; PFS: progression-free survival; R: randomized; OL: Open label; UC: uncontrolled; RA: Retrospective analysis; CS: Cohort study; AI: aromatase inhibitor; TTP: time to progression. 
| Ref. | Pts | Study type | Diagnosis | Treatment | Results |
|------|-----|------------|-----------|-----------|---------|
| Asaishi et al. [68], 1993 | 51 women | Not stated | Advanced breast cancer refractory to TAM | TOR 120 mg | 11.8% CR + PR | SD > 6 mo Median duration of response 127 d |
| Gams et al. [69], 2002 | 102 women peri- or post-menopausal women | Pr | Advanced breast cancer refractory to TAM | TOR 200 mg | 5% OR | 15.7% SD | Median duration of SD > 6 mo 238.5 d |
| Pyrhönen et al. [70], 1994 | 50 Women | Pr | Advanced breast cancer refractory to TAM | TOR 240 mg | 4% RR | Mixed response 6% SD | 18% < 5 mo 26% > 5 mo |
| Hietanne et al. [71], 1997 | 73 post-menopausal women | Pr | Advanced breast cancer | TOR 240 mg | OR (CR + PR) 59% | NC | PD 12% |
| Yamamoto et al. [72], 2005 | 10 Women | RA | Metastatic breast cancer | TOR 120 mg | OR 30% CR | CB | 58.30% TTF 7.8 mo |
| Ohtake et al. [73], 2009 | 12 post-menopausal women who had failed AI therapy | RA | Advanced/recurrent breast cancer | TOR 120 mg | CR 16.70% | CB | Mean TTP 21.5 mo |
| Okita et al. [74], 2009 | 15 women | Pr | Metastatic breast cancer | TOR 120 mg, Paclitaxel 80 mg/m² on 5 d | CR 0% | PR 6.7% | No change 66.7%, Stable > 6 mo 26.7% PD 26.7% Mean TTP 2.7 mo |
| Koyama et al. [75], 2011 | 19 post-menopausal women | RA | Advanced or metastatic breast cancer | TOR 120 mg | OR 36.8% (1 CR, 6 PR 6) | CB | 47.4% |
| Gu et al. [76], 2012 | 810 pre-menopausal women | RA | Early invasive breast cancer (adjuvant treatment) | TOR 60 mg, TAM 20 mg | OR 100% 98.4 (mo)% | CB | DFS 97.2% 90.4% (P = 0.022) |
| Sawaki et al. [77], 2012 | 13 post-menopausal women | Pr | Adjuvant aromatase inhibitor resistant metastatic breast cancer | TOR 120 mg | CR 7.7% | SD | PD 38.5% CB 46.2% PFS 5.9 mo |
| Tokura et al. [78], 2012 | 18 women | Pr | Advanced/recurrent breast cancer | TOR 120 mg | CR 58% (5 PR, 5 long SD) | CB | PD 22% Media PFS 5.5 mo |
| Koike et al. [79], 2013 | 21 | Pr | Recurrent or metastatic breast cancer | TOR 120 mg | CR (12 wk) 0% | PR/SD (12 wk) 13% | CB | 78.30% Median TTP 8.1 mo |
| Ogata et al. [80], 2013 | 23 women | Pr | Recurrent breast cancer who were receiving or had received adjuvant aromatase inhibitor therapy | TOR 120 mg | CR 13% | SD | CB | 78.30% Median TTP 8.1 mo |
| Qin et al. [81], 2013 | 1847 pre-menopausal women | RA | Operable breast cancer (adjuvant treatment) | TOR 60 mg, TAM 20 mg | DFS 10.3 yr 10.3 yr | 5-Yr DFS 87% 85% 5-Yr OS 94.3% 93.5% |

DB: Double blind; CR: Complete response; PR: Partial response; SD: Stable disease; LSD: Long stable disease; TOR: Toremifene; TAM: Tamoxifen; DFS: Disease-free survival; OS: Overall survival; (O)RR: (Objective) response rate; CB: Clinical benefit; DFS: Disease-free survival; PFS: Progression-free survival; R: Randomized; OL: Open label; UC: Uncontrolled; RA: Retrospective analysis; CC: Case control; Pr: Prospective; CS: Cohort study; AIU: Aromatase inhibitor; TTP: Time to progression.
Toremifene in early stage breast cancer

The International Breast Cancer Study group combined the results from two studies with almost identical protocols in which a total of 1035 peri- or post-menopausal women with breast cancer received either toremifene 60 mg or tamoxifen 40 mg \[^{31}\]. In common with other similar studies the efficacy of toremifene and tamoxifen were approximately equal; 5-year disease-free survival was 72% and 69% respectively and 5-year overall survival was 85% and 81%. Likewise, in an even larger randomized study in [North American Fareston vs Tamoxifen Adjuvant (NAFTA) trial] \[^{18}\] 1813 peri- or post-menopausal women with invasive breast cancer toremifene 60 mg and tamoxifen 20 performed similarly (5-year disease-free survival 92.2% in both groups)

After a median follow-up of 3.4 years a Finnish study found a number of efficacy parameters showing advantages for toremifene compared with tamoxifen, although none achieved statistical significance. Overall, time to recurrence, recurrence rate, recurrence at distant sites and the number of patients dying during follow-up were similar in toremifene- and tamoxifen- treated patients. Although the Kaplan-Meir analysis of the time to recurrence or the time to progression or disease free survival in this study (Figure 1) appears to show a separation between toremifene and tamoxifen from 3 years onwards, the difference is not statistically significant (hazard ratio toremifene:tamoxifen 0.88 (95%CI: 0.70-1.09). The respective 5-year survival rates were 70.3% vs 65.6% (also not statistically significantly different)\[^{33}\].

Whilst most randomized controlled studies of toremifene have been performed in patients with advanced or metastatic disease, another small study has been undertaken in an adjuvant setting in women with early stage breast cancer; 91 post-menopausal women with early stage, lymph node negative breast cancer were randomized to adjuvant treatment with toremifene 120 mg or tamoxifen 20 mg \[^{16}\]. Five-year survival (97% and 96.7% respectively), cumulative disease-free survival (97.5% and 97.3% respectively) and cumulative disease-free survival (88.5% and 90.6% respectively) were very similar between the two groups after 66.5 mo follow-up.

Non-randomized trials

Whilst there are at least 14 published non-randomized studies of toremifene in advanced breast cancer many include rather few patients or have imperfect methodologies. However, there are two recent retrospective studies that merit further description

The study of Gu \[^{40}\] reviewed the records of 810 women with early invasive breast cancer and identified 240 eligible patients who had received tamoxifen and 212 who had received toremifene. Following median follow-up times of 50.8 mo, although 5-year overall survival rates were similar (100% for toremifene and 98.4% for tamoxifen), recurrence-free survival was significantly longer in the toremifene group than in the tamoxifen (97.2% and 90.4% respectively, \(P = 0.022\)).

Another retrospective study, this time including 1847 pre-menopausal women who had undergone surgery followed by chemotherapy toremifene or tamoxifen similarly found no significant differences between the
All survival figures were identical between toremifene and tamoxifen; disease-free survival (10.3 years in both groups). Five-year disease-free survival (87% vs 85%, respectively) and 5-year overall survival (94.3% vs 93.5%, respectively) were also comparable.

META-ANALYSES

Whilst individual clinical trials can provide invaluable data on the efficacy of a medication in restricted populations, meta-analysis can provide information about more generalized patient populations and increase statistical power. The randomized clinical trials described above have been the subject of several meta-analyses. The earliest combined two randomized studies comparing toremifene (200 or 240 mg) and tamoxifen (20 or 40 mg) and included a total of 733 patients with advanced breast cancer. Response rates were higher in toremifene patients than in tamoxifen patients (25.2% vs 19.8%), but not statistically significantly ($P = 0.87$). Disease progression and survival also showed no statistically significant differences between toremifene and tamoxifen.

A subsequent meta-analysis in 1999 included results from the five randomized studies completed to that date. This meta-analysis represented 1421 postmenopausal patients with previously untreated, locally advanced or metastatic breast cancer that were treated with either toremifene 40-60 mg ($n = 725$) or tamoxifen 20-40 mg ($n = 696$). As in the previous meta-analysis toremifene and tamoxifen proved to be broadly equivalent in terms of response rate (24.0% vs 25.3%, respectively), time to treatment failure (4.9 vs 5.3 mo) and survival (31.0 vs 33.1 mo).

Another meta-analysis has been performed on the disease-free and overall survival findings from two pivotal randomized studies comparing toremifene and tamoxifen in an early breast cancer subgroup of patients, the combined data showed a significant ($P = 0.037$) benefit for toremifene with regard to disease-free survival, although the difference with regard to overall survival did not achieve statistical significance ($P = 0.059$).

A more recent meta-analysis using somewhat more restrictive criteria for inclusion analyzed three eligible randomized comparisons with tamoxifen. However, the overall results were similar in that no significant differences in efficacy between toremifene and tamoxifen were identified with risk ratios close to unity for overall survival and disease-free survival.

A recent meta-analysis identified 23 randomized clinical trials comparing toremifene with tamoxifen involving a total of 7242 patients with breast cancer. This large study found that although for most efficacy parameters there were no significant differences between toremifene and tamoxifen, toremifene was significantly more effective in terms of 5-year survival (odds ratio (OR) 1.25; 95%CI: 1.04-1.50) among patients with early stage breast cancer.

A Cochrane review on toremifene vs tamoxifen for advanced breast cancer compared randomized controlled comparisons providing data on objective response rates, DFS all

|          | DFS ER+ | OS all | OS ER+ |
|----------|---------|--------|--------|
| FBCG     |         |        |        |
| IBCSG    |         |        |        |
| Combined |         |        |        |

DFS: Disease-free survival; OS: Overall survival; IBCSG: International Breast Cancer Study Group; FBCG: Finnish Breast Cancer Group.
time to progression and overall survival.\(^{[66]}\)

The review identified 2061 patients from seven studies (1226 patients received toremifene and 835 patients received tamoxifen). The pooled risk ratio for the objective risk ratio was 1.02 suggesting that there was no statistically significant difference between toremifene and tamoxifen (objective risk ratios (ORR) were 25.8\% vs 26.9\%, respectively). Similarly the hazard ratio for time to progression was 1.08, again, implying no statistically significant difference between toremifene and tamoxifen (time to progression 6.1 mo and 5.8 mo respectively). Overall survival also showed equivalence between the two medications [hazard ratio (HR) 1.02; overall survival 27.8 mo and 27.6 mo respectively]. The authors conclude that toremifene and tamoxifen are equally effective in the first-line treatment of patients with advanced breast cancer.

The results of the randomized clinical trials are remarkably consistent and supported by both meta-analyses and retrospective studies; toremifene is at least as effective as tamoxifen in the treatment of breast cancer. Rather few studies find significant differences between the two SERMs, those that do differentiate between the two treatments find significant differences in favor of toremifene.\(^{[31,37,38]}\) None find significant advantages for tamoxifen.

**Safety and tolerability**

Toremifene and tamoxifen have similar adverse event profiles and are well tolerated, both in women with advanced breast cancer and in those receiving adjuvant therapy. Hot flushes, sweating, nausea and vaginal discharge are among the most common adverse effects and serious adverse events are rare.

A large retrospective analysis of 1847 breast cancer patients treated with toremifene or tamoxifen showed the expected pattern of adverse events with sweating and nausea/vomiting as the most common undesirable effects (Table 3). Although the great majority of adverse effects occurred at similar rates in toremifene- and tamoxifen- treated patients, irregular menses were significantly more common in the tamoxifen group (10\% vs 6.3\%, \(P = 0.025\)).\(^{[41]}\)

In the largest randomized study comparing toremifene and tamoxifen there were few differences in thromboembolic, gynecological and ocular adverse events between the two treatment groups. Fever and chills were significantly more common among tamoxifen-treated patients.\(^{[39]}\)

A safety analysis in the Finnish Breast Cancer Study Group data also illustrates the similar tolerability and safety profiles of toremifene; sweating and hot flashes being observed in more than half of the patients, followed by vaginal dryness and discharge with itching and depression observed in more than 20\% of patients.\(^{[32]}\) In no case were significant differences between toremifene and tamoxifen observed. There was similarly little difference in the incidence or pattern of serious adverse events between toremifene and tamoxifen (Table 5).

The above described studies were conducted with the low dose toremifene (60 mg), however high dose toremifene 200 or 240 mg is not associated with a significantly increased incidence, or different profile, of adverse events compared with the 60 mg dose.\(^{[33]}\) For example, in a randomized study that involved 648 women with metastatic breast cancer, with the exception of a slightly greater incidence of nausea in the high dose group, the incidence of the most common side effects was similar with toremifene 60 mg and 200 mg.\(^{[30]}\) Similarly, there were no significant differences between the incidence of side effects with toremifene 60 mg and 240 mg in a randomized study of 463 women with advanced breast can-

### Table 3 Incidence of adverse events among 1847 women with invasive breast cancer treated with tamoxifen or toremifene\(^{[41]}\)

| Adverse event           | Tamoxifen (\(n = 1451\)) | Toremifene (\(n = 396\)) | \(P\) value |
|-------------------------|---------------------------|--------------------------|-------------|
| Flushing                | 480 (33.1)                | 39 (35.1)                | 0.450       |
| Sweating                | 295 (20.3)                | 82 (20.7)                | 0.869       |
| Nausea or vomiting      | 213 (14.7)                | 57 (14.4)                | 0.881       |
| Fatigue                 | 74 (5.1)                  | 18 (4.9)                 | 0.653       |
| Insomnia                | 62 (4.3)                  | 14 (3.5)                 | 0.513       |
| Dizziness               | 14 (1.0)                  | 6 (1.5)                  | 0.408       |
| Dry eyes                | 60 (4.1)                  | 17 (4.3)                 | 1           |
| Blurred vision          | 40 (2.8)                  | 9 (2.3)                  | 0.595       |
| Cataracts               | 7 (0.5)                   | 2 (0.5)                  | 1           |
| Weight gain             | 68 (4.7)                  | 17 (4.3)                 | 0.740       |
| Vaginal discharge       | 241 (16.6)                | 69 (17.4)                | 0.701       |
| Irregular menses        | 145 (10.0)                | 25 (6.3)                 | 0.025       |
| Endometrial cancer      | 1 (0.1)                   | 0 (0)                    | 0.601       |
| Ovarian cyst            | 20 (1.4)                  | 4 (1.0)                  | 0.631       |
| Thromboembolic events   | 22 (1.5)                  | 5 (1.3)                  | 0.709       |
| Hypertriglyceridemia    | 76 (5.2)                  | 19 (4.8)                 | 0.725       |
| Hyper-LDL cholesterolia | 65 (4.5)                  | 16 (4.0)                 | 0.783       |
| Fatty liver             | 64 (4.4)                  | 13 (3.3)                 | 0.320       |
| Elevated ast            | 59 (4.1)                  | 15 (3.8)                 | 0.802       |
| Elevated alp            | 33 (2.3)                  | 7 (1.8)                  | 0.571       |
| Hepatic cyst            | 29 (2.0)                  | 6 (1.5)                  | 0.550       |
| Bilirubin               | 27 (1.9)                  | 8 (2.0)                  | 1           |

### Table 4 Frequency of subjective adverse events among 499 patients with invasive breast cancer randomised to adjuvant toremifene or tamoxifen therapy\(^{[12]}\)

| Adverse event    | Tamoxifen | Toremifene | \(P\) value |
|------------------|-----------|------------|-------------|
| Sweating         | 247       | 225        | 0.114       |
| Hot flashes      | 237       | 209        | 0.114       |
| Vaginal discharge| 193       | 156        | 0.114       |
| Vaginal dryness  | 120       | 117        | 0.332       |
| Itching          | 118       | 119        | 0.332       |
| Depression       | 112       | 119        | 0.332       |
| Rash             | 90        | 75         | 0.332       |
| Nausea           | 78        | 85         | 0.332       |
| Vaginal bleeding | 40        | 37         | 0.332       |
| Diarrhea         | 37        | 51         | 0.332       |
| Weight increase  | 23        | 19         | 0.332       |
In a pooled-analysis of two studies involving 733 women with advanced breast cancer\(^3\), high-dose toremifene 200 or 240 mg was tolerated as well as tamoxifen 20 or 40 mg.

In a meta-analysis of five studies significantly more tamoxifen- than toremifene-treated patients discontinued treatment prematurely (19.6\% vs 13.7\%; \(P = 0.007\)), predominantly due to greater non-compliance and protocol violations in the tamoxifen group\(^4\). Not every study shows identical tolerability; in the Nordic study\(^5\), the percentage of patients discontinuing treatment prematurely was significantly lower with toremifene than with tamoxifen (14\% vs 20\% respectively; \(P = 0.011\)), mainly due to fewer adverse events/patients’ refusals, loss to follow-up and deaths.

The recent meta-analysis of Chi et al\(^6\) however, showed that compared with tamoxifen, toremifene was associated with more vaginal discharge in patients with early stage breast cancer and more vaginal bleeding in patients with advanced disease, although the both drugs had a similar overall effect on quality of life.

### Lipids

As the long-term prognosis for breast cancer patients improve, increasing attention has been focused on continuing quality of life and morbidity from other causes.

This is particularly important when SERMs are used in an adjuvant setting in early-stage breast cancer where the probability of long-term survival is high. In this context, an attractive property of SERMs is their ability to improve cardiovascular risk factors. Toremifene reduces both total and low-density lipoprotein (LDL) cholesterol and increases high-density lipoprotein (HDL) cholesterol (Figure 3)\(^7-8\). Particularly persuasive are the results from a crossover trial in which 197 women receiving adjuvant therapy with toremifene or tamoxifen were monitored for lipid levels\(^9\). After one year of treatment the total cholesterol had decreased in both groups, but HDL-cholesterol increased only in the toremifene group (\(P < 0.001\)); indeed, HDL cholesterol significantly decreased in the tamoxifen-treated patients (\(P < 0.001\)). After one year of therapy patients who still had abnormal lipid levels were switched to the other medication. In patients switched from tamoxifen to toremifene total- and HDL-cholesterol increased and triglycerides decreased to pre-treatment levels whilst in the patients switched from toremifene to tamoxifen total cholesterol decreased and triglycerides increased. The authors conclude that the lipid profile changes associated with toremifene are better than those associated with tamoxifen\(^9\). This finding was supported by the results of a recent meta-analysis of 23 clinical trials in which toremifene and tamoxifen were compared\(^4\).

In an early stage breast cancer patients’ triglyceride levels were reduced more and HDL-cholesterol levels increased more by toremifene than by tamoxifen, although tamoxifen was more effective in reducing LDL-cholesterol. In patients with advanced disease toremifene also reduced triglyceride levels more than tamoxifen.

Similar beneficial changes have also been reported from an extended randomized controlled investigation of the effects of toremifene in the aromatase inhibitor anastrozole on lipid profile\(^6\).

The evidence seems rather clear that the effect of toremifene on patients’ lipid profile is generally positive and better than that of the comparator treatments so far investigated.

### Bone mineral density in breast cancer patients

Toremifene improves bone mineral density (BMD) and helps prevent osteoporosis in postmenopausal breast cancer patients. These effects are similar to those of

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**Table 5** Frequency of serious adverse events among 499 patients with invasive breast cancer randomised to adjuvant toremifene or tamoxifen therapy\(^31\)

|                | Toremifene | Tamoxifen |
|----------------|------------|-----------|
| Number of patients | 72         | 74        |
| %               | 15.7       | 16.8      |
| Cardiac events   | 9          | 2         |
| %               | 2.0        | 1.4       |
| Myocardial infarctions | 7       | 5         |
| %               | 1.5        | 1.1       |
| Angina pectoris  | 2          | 1         |
| %               | 0.4        | 0.2       |
| Thromboembolic events | 16      | 26        |
| %               | 3.5        | 5.9       |
| Pulmonary embolisms | 3        | 3         |
| %               | 0.7        | 0.7       |
| Deep vein thrombosis | 8       | 11        |
| %               | 1.7        | 2.5       |
| Cerebrovascular events | 5       | 12        |
| %               | 1.1        | 2.7       |
| Endometrial events | 17      | 19        |
| %               | 3.7        | 4.3       |
| Polyps          | 8          | 7         |
| %               | 1.7        | 1.6       |
| Hemorrhage      | 2          | 0.4       |
| %               | 0.4        | 0.5       |
| Disorders       | 7          | 1         |
| %               | 1.5        | 2.0       |
| Subsequent cancers | 12      | 26        |
| %               | 2.6        | 1.8       |
| Breast          | 3          | 0.7       |
| %               | 0.7        | 1.2       |
| Uterine         | -          | 2         |
| %               | -          | 0.5       |
| Gastrointestinal | 3          | 1         |
| %               | 0.7        | 0.2       |
| Other           | 6          | 1         |
| %               | 1.3        | 0.2       |
| Cataracts       | 3          | 0.7       |
| %               | 0.7        | 1.8       |
| Increased liver enzyme levels | 2    | 2         |
| %               | 0.4        | 0.5       |
| Bone fractures  | 13         | 28        |
| %               | 2.8        | 5.1       |
| Osteoporotic    | 2          | 0.4       |
| %               | 0.4        | 0.7       |

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**Figure 3** Percentage change in lipid parameters after one year with toremifene and tamoxifen\(^9\): 1: Total cholesterol; 2: low-density lipoprotein (LDL) cholesterol; 3: high-density lipoprotein (HDL) cholesterol; 4: Triglycerides; 5: LDL-HDL; 6: Apo lipoprotein-B.
tamoxifen. Comparative studies have shown that both
toremifene and tamoxifen prevent reductions in BMD
in the lumbar spine and proximal femur, and that these
effects are reflected by changes in a wide range of bone
biochemistry markers such as pyridinoline, deoxypyridino-
noline and urinary cross-linked aminoterminal telopep-
tide of type 1 collagen[53-55]. Toremifene and tamoxifen
have also been used successfully in combination with the
bisphosphonate clodronate, with no significant differ-
ences between them[56,57].

Some beneficial effects on BMD have been observed
in premenopausal women at high risk for developing
breast cancer taking toremifene 60 mg as chemopreven-
tion, therefore making an attractive alternative to tamoxi-
fen. A double-blind, placebo- controlled pilot study in
259 healthy premenopausal and postmenopausal women
at high risk for breast cancer found a trend for a sus-
tained increase in lumbar spine BMD after one year of
toremifene therapy in premenopausal women[58].

LONG TERM SAFETY

The long-term safety profile of toremifene was evaluated in
detail in a review of all preclinical and clinical safety
data from 1978 to 2004 and comparative clinical safety
data between October 1995 and the end of 2004[59]. At
the time of this review, information was available from
more than 350000 patient treatment years. The evidence
indicated that toremifene has good long-term safety, with
a lower incidence of endometrial cancer, stroke, pulmo-
mary embolism, deep vein thrombosis and cataracts than
tamoxifen.

A 3-year study specifically designed to compare the
gynecological effects of toremifene 40 mg and tamoxi-
fen 20 mg in 167 postmenopausal breast cancer patients
showed that the incidence of proliferative endometrium
was increased to a significantly (P < 0.0001) lesser extent
by toremifene (from 20.0% to 32.2%) than by tamoxifen
(from 20.4% to 46.8%)[58].

Endometrial cancer

The finding that tamoxifen at high doses caused liver tu-
mors in rats[61] raised concern that it may be mutagenic in
humans. The mechanism of this effect in laboratory ani-
malst was believed to be due to DNA adduct formation
by metabolites of tamoxifen, although this has more re-
cently been questioned[62]. Nevertheless, endometrial
cancer rates are increased in women taking tamoxifen[13].
The chlorination substitution in the structure of toremifene alters
its metabolism such that DNA adducts are much less
likely to form[13,63-65]. A case-control study based on
records of 38000 Finnish breast cancer patients appears
suggest that toremifene is considerably less frequently
associated with endometrial cancer than is tamoxifen[13].
However, a recent meta-analysis of studies involving a total of 7242
patients with early or advanced breast cancer found no
difference in the number of endometrial cancers between
patients treated with toremifene or tamoxifen, although
the follow-up was relatively short in the majority of stud-
ies. There is clearly still much to be discovered concern-
ing the oncogenicity of SERMs, but both laboratory and
clinical evidence suggests an advantage for toremifene
over tamoxifen in this regard.

Thromboembolic effects

A retrospective analysis of the serious vascular events
reported in the manufacturer’s Drug Safety Database[67]
revealed that cerebrovascular and thromboembolic events
overall were significantly higher in tamoxifen than in
toremifene-treated patients (Figure 4).

Other evidence suggests that toremifene may be
associated with a lower risk of such thromboembolic
events[59]. A retrospective analysis of adjuvant treatment
trials with toremifene 40 or 60 mg and tamoxifen 20 mg
in more than 2500 postmenopausal women revealed a
significantly lower incidence of ischemic stroke, total
cerebrovascular events and total thromboembolic events
with toremifene compared with tamoxifen.

DISCUSSION

For obvious ethical reasons the great majority of rand-
omized clinical trials of toremifene have been undertaken
with tamoxifen as the comparator, rather than placebo.
The results of these studies, and the several meta-
analyses that are based upon them, appear to character-
ize toremifene as being at least as effective as tamoxifen
in the treatment of breast cancer both in the adjuvant
setting and in patients with advanced and metastatic dis-
ease. Of the ten randomized controlled trials described
in Table 1 all found toremifene to be at least as effective
as tamoxifen. In some studies and for some parameters
there was a statistically significant advantage for toremi-
fone over tamoxifen; a shorter time to onset of complete
response in Nomura et al[59] 1993, a higher rate of objec-
tive response in Zejnullahov et al[59] 2006 and a longer pro-
gression-free survival in Yamamoto et al[59] 2013. There

![Figure 4 Incidence of serious vascular events in patients randomized to
toremifene or tamoxifen adjuvant therapy in post-menopausal women[59].]
were no statistically significant efficacy advantages for tamoxifen in these studies. However, whilst it is tempting to claim at least a trend for better efficacy for toremifene, some statistically significant differences are likely to arise by chance when a large number of parameters are compared in several studies (68 individual parameters are represented in Table 1 far more were examined in the studies cited). So far as the efficacy of toremifene is concerned, the conclusion is that it is at least as effective as tamoxifen is reasonable seems conservative and reasonable. In addition, toremifene has been the subject of a number of meta-analyses using different criteria for inclusion of studies and all have come to the same conclusion that the efficacy of toremifene and tamoxifen are not statistically significantly different.

Modern hormonal treatment for breast cancer emphasizes continuing therapy with an anti-estrogen, or an anti-estrogen followed by a switch to an aromatase inhibitor after longer or shorter periods. Whilst toremifene appears to behave similarly to tamoxifen, there is a relative dearth of information on its use in these switch or extended adjuvant contexts.

So far as safety and tolerability are concerned, the simple substitution of a chlorine atom for a hydrogen atom appears to make a considerable difference. The altered pattern of metabolite formation with its strongly reduced DNA adduct formation is reflected in a lower incidence of endometrial cancer—a recent meta-analysis of studies involving a total of 7242 patients with early or advanced breast cancer found no difference in the number of endometrial cancers between patients treated with toremifene or tamoxifen, although the follow-up was relatively short or tamoxifen, although the follow-up was relatively short in the majority of studies[44]. On the other hand, the pattern of serum lipids is more favorably affected by toremifene with lower triglycerides, and an improved HDL/total cholesterol ratio. Thromboembolic events also show tolerted and the pattern of adverse events reported in clinical trials is rather similar between the two SERMs.

Taken together, the findings of clinical trials, meta-analyses and studies on specific aspects of the pharmacology of toremifene suggest that it is an effective and well tolerated agent for the treatment of early and advanced breast cancer. In comparison with tamoxifen, toremifene is at least as effective in all therapeutic contexts so far investigated and may have tolerability and safety advantages.

ACKNOWLEDGMENTS

Editorial assistance was provided by Dr. JF Stolz. This assistance was reimbursed by Orion Pharma, Espoo, Finland.

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P- Reviewer: Markopoulos C, Vetvicka V  S- Editor: Ji FF  L- Editor: A  E- Editor: Lu Y
