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Assessment of Clinical and Biochemical Effects

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Vitamin D and its metabolites via binding to cellular vitamin D receptors principally regulate bone homeostasis, but also have been observed to be potent growth inhibitors of neoplastic cells. Preclinical work has strongly implied vitamin D-based therapy could be effective in prostate cancer. Early clinical work with vitamin D has been complicated by its significant calcemic effects. 1 $\alpha$ -OH-D<sub>2</sub> is a vitamin D analog with less calcemic effects but significant growth inhibitory effects. Objective anti-tumor activity was observed in a prostate cancer patient during an initial phase I study of 1 $\alpha$ -OH-D<sub>2</sub>. We are performing a phase II study of daily 1 $\alpha$ -OH-D<sub>2</sub> in patients with advanced androgen-independent prostate cancer. We have observed transient mild hypercalcemia without symptoms in selected patients. No objective tumor responses have been observed to date and the study is too early to discuss the primary endpoint of time-to-treatment failure. Pilot correlative studies evaluating plasma transforming growth factor  $\beta$ 1 levels and T cell receptor-associated signal transducing  $\zeta$  chain expression in peripheral mononuclear cells in patients undergoing study participation are underway without significant preliminary data. Observations to date continue to support the possibility that therapy with daily 1 $\alpha$ -OH-D<sub>2</sub> in androgen-independent prostate cancer could be effective.

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## Introduction

The finding of vitamin D receptors (VDRs) in many different cells, including normal and malignant prostate cells, and the corresponding observation in these same cells that vitamin D metabolites can regulate cell growth and promote differentiation via VDRs has strongly implied a potential role for these metabolites in cancer prevention or therapy. Epidemiologic studies and *in vitro* studies observing physiologic levels of vitamin D ( $1\alpha,25(\text{OH})_2\text{D}_3$ ) inhibiting proliferation of prostate cancer cells support this implication. The clinical development of vitamin D metabolites/analogs has been slowed by their calcemic activity.  $1\alpha\text{-OH-D}_2$  is an analog with significantly less calcemic activity than  $1\alpha,25(\text{OH})_2\text{D}_3$  but with similar potency in inhibiting cancer cell proliferation. It has been administered chronically to osteopenic patients without serious sequelae and has recently undergone phase I testing (daily, oral  $1\alpha\text{-OH-D}_2$ ) in hormone refractory prostate cancer patients. Transient grade 1 or 2 hypercalcemia was dose-limiting at 12.5 to 15  $\mu\text{g/day}$ . Objective evidence of anti-tumor activity was observed in one patient and multiple other patients had stable disease lasting > 6 months. Based on these preliminary data a phase II study of daily (12.5  $\mu\text{g/day}$ )  $1\alpha\text{-OH-D}_2$  in hormone refractory prostate cancer patients was recently begun. The primary endpoint is time-to-disease progression and survival. Two main pilot correlative studies are being performed, measurement of plasma  $\text{TGF}\beta_1$  levels and T cell receptor (TCR)-associated signal transducing  $\zeta$  chain expression in PBLs in patients before, during and after  $1\alpha\text{-OH-D}_2$  therapy. These assays will hopefully provide insight into  $1\alpha\text{-OH-D}_2$  mechanistic issues and/or provide surrogate markers of clinical benefit secondary to  $1\alpha\text{-OH-D}_2$ . Additional correlative studies include assessment of VDR status in patient tissue blocks, PSA determinations, and evaluation of bone turnover markers. Nine patients have been entered to date with 2 patients still on study with stable disease at 6 and 2 months. No unexpected toxicities have been observed. Pilot correlative study data is being collected but has not been analyzed to date. Patient enrollment continues. The preliminary data strongly suggest hormonal therapy with vitamin D analogs could be an effective therapy for hormone refractory prostate cancer, which currently has no proven effective therapy.

## Body

### Review of Statement of Work

|                          |   |
|--------------------------|---|
| Task 1 (Aim 1)           | Phase II study of $1\alpha\text{-OH-D}_2$ in androgen-independent prostate cancer patients. |
| Months 1 – 24:           | Patient recruitment, enrollment and study participation                                     |
| Months 24-30:            | Continued patient follow-up, data interpretation  |
| Tasks 2 & 3 (Aims 2 & 3) | Pilot study of laboratory correlates.   |
| Months 1 – 24:           | Assay performance   |
| Months 24-30:            | Data interpretation   |

Year 1 (Months 1-12)  
Task 1 Phase II study of  $1\alpha$ -OH-D<sub>2</sub> in androgen-independent prostate cancer patients.

The study did not obtain all final administrative approvals until January 1999. Study accrual began with the recommended phase II dose of 12.5  $\mu$ g/day of  $1\alpha$ -OH-D<sub>2</sub>. Nine patients have been accrued through the January 1999 through July 1999. Two patients are still active with stable disease at 6 and 2 months of study participation. Seven patients were removed from study with progressive disease per bone scan or CT scan. They were onstudy for 1 – 7 months. No objective responses have been observed. Transient grade 1 hypercalcemia has been observed in 5 of 9 patients. *N.B.* Due to safety concerns, any degree of hypercalcemia is considered dose-limiting and requires study drug discontinuation followed by a dose reduction when the hypercalcemia resolves. There has been no occurrence of symptomatic hypercalcemia. Only 1 of 9 enrolled patients has died. This patient died of progressive disease 3 months after stopping study drug. Patient enrollment continues at the expected rate.

The projected goal was approximately 20 patients per year. From the start of the protocol we are on schedule, from the start of the grant period (3 months earlier) we are slightly behind. No changes are planned in patient recruitment.

Relative to the hypothesis of vitamin D based therapies becoming an additional effective hormonal therapy, no conclusions can be drawn.

#### Task 2&3. Laboratory Correlative Studies.

One of the main goals of the correlative studies is to explore potential ways of predicting likelihood of benefit either before or early in vitamin D-based therapy in androgen-independent prostate cancer patients. The studies listed below are being evaluated for that purpose and due to the possibility prostate-specific antigen (PSA) levels will be misleading.

Plasma transforming growth factor  $\beta_1$  (TGF $\beta_1$ ). Prior preclinical work with vitamin D analogs has noted an association between increased expression of the negative growth factor TGF $\beta$  and growth inhibition. We are examining serial plasma TGF $\beta_1$  in patients undergoing therapy with  $1\alpha$ -OH-D<sub>2</sub> in order to assess any possible mechanistic relationships but also to determine if plasma TGF $\beta_1$  levels during  $1\alpha$ -OH-D<sub>2</sub> therapy could antedate objective clinical responsiveness. These samples have been collected and the assays are being run. No preliminary data is available.

Expression of Signal-transducing  $\zeta$  Chains in peripheral T and NK cells. Evaluation of T cell receptors (TCR), primarily  $\zeta$  chain, has been correlated with disease state in prostate cancer patients as well as other malignancies. Vitamin D also has been implicated in multiple immune mediated activities. As with TGF $\beta$ , we are assessing  $\zeta$  chain TCR status as a possible mechanistic and predictive laboratory correlate. We have been collecting whole blood samples and separating peripheral mononuclear cells by ficoll-

hypaque gradient. Flow cytometric evaluation of TCR- $\zeta$  status is ongoing with very preliminary data available which has not been analyzed. No obvious early trends indicative of  $1\alpha$ -OH-D<sub>2</sub> clinical effects are evident.

Bone turnover markers. Serum osteocalcin and urinary levels of hydroxyproline are indirect measures of osteoblastic activity and bone resorption. These studies were proposed to better understand the effects of vitamin D-based therapy on bone metabolism. These studies are being collected but have not been run/analyzed to date.

Vitamin D receptor status (VDR). It is hypothesized the growth inhibitory effects of  $1\alpha$ -OH-D<sub>2</sub> are via interaction VDR and the eventual downstream effects of this interaction. Therefore, similar to antiestrogens in breast cancer and antiandrogens in prostate cancer, determination of the specific receptor status can be helpful in predicting clinical benefit. Paraffin blocks from primary tumor biopsies are being collected, when available. No ligand-binding studies have been performed to date.

### **Key Research Accomplishments**

The project is moving forward as predicted with expected accrual rates and ongoing data collection. No key research accomplishments have been noted to date.

### **Reportable Outcomes**

None.

### **Conclusions**

Patient accrual continues on the Phase II study of daily  $1\alpha$ -OH-D<sub>2</sub> in androgen-independent prostate cancer patients. The early experience with the study reinforces the concept that vitamin D-based therapy can be given safely to prostate cancer patients and the main/exclusive toxicity is transient hypercalcemia. The remaining important issue this study plans to address is whether clinical benefit is derived from vitamin D-based therapy, in this case with  $1\alpha$ -OH-D<sub>2</sub>. We have noted a high rate (4/9) of grade 1 hypercalcemia, which per protocol requires a dose reduction. Therefore many patients are not being treated at the initial recommended phase II dose of 12.5  $\mu$ g/day. This increased incidence of required dose reductions is due to not allowing any hypercalcemia during the phase II study as compared to allowing grade 1 hypercalcemia during the phase I study. This change was incorporated due to concerns regarding associated renal toxicity with grade 2 hypercalcemia encountered towards the end of the phase I study (after submission/approval of this DOD project). No conclusions can yet be made regarding the clinical viability of  $1\alpha$ -OH-D<sub>2</sub> in prostate cancer.

The laboratory correlative studies are ongoing as well, without any meaningful preliminary data at this time. No difficulties have been encountered or are expected in regards to collecting or performing these studies. Again, the main issue is whether they will have any clinical significance.

The ongoing value of this project mainly pertains to the novelty of the therapeutic area as well as the study design itself. As mentioned above, the study continues to prove vitamin D analogs can be given safely to prostate cancer patients at levels greater than vitamin D can be administered. This is significant not only in the arena of therapeutics but also in the area of chemoprevention. Vitamin D-based therapies are of great interest in the prevention of many cancers. This is also significant for other cancer types. Another potential important area this study is exploring, "Is whether mechanistic correlates can be early predictors of clinical benefit?" This is an important area, since most "cytostatic" agents are frequently given for many months before an assessment for clinical benefit is made. If this study were to determine prestudy correlative values or correlative effects during the first few weeks of therapy were predictors for eventual clinical benefit, the value of these findings is self-explanatory.

### **References**

None.

### **Appendices**

None.